SULPHUR

The Magazine of World Sulphur Industry

No. 24 *APRIL, 1959*

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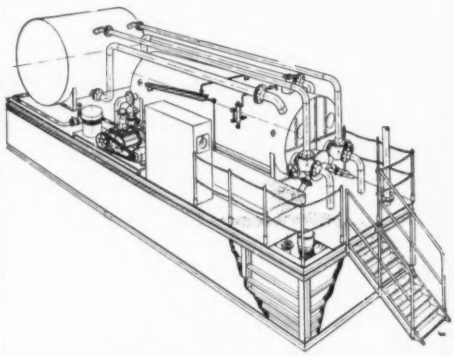

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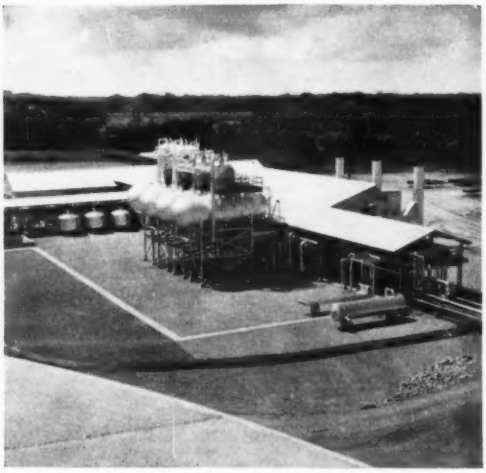

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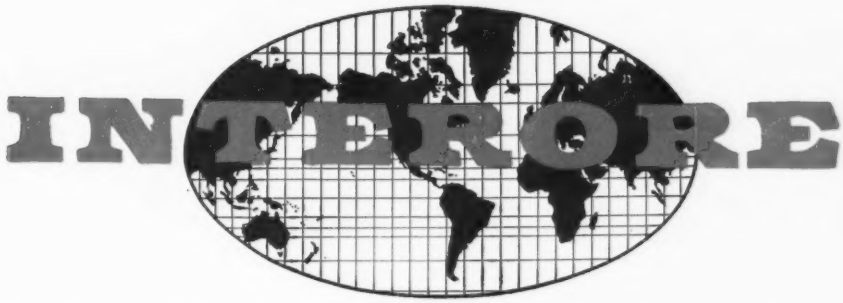

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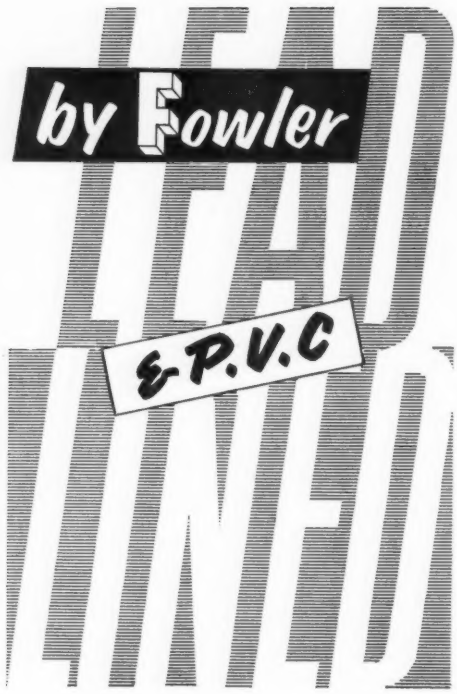

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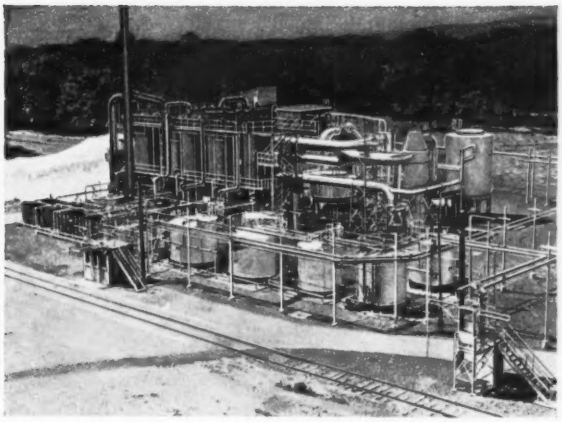

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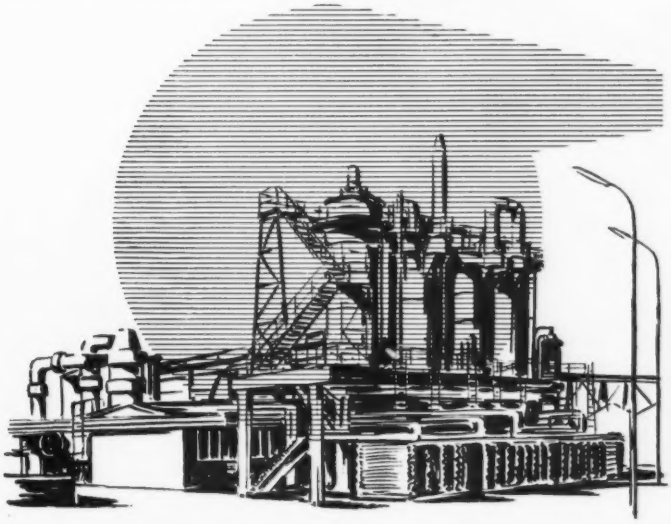

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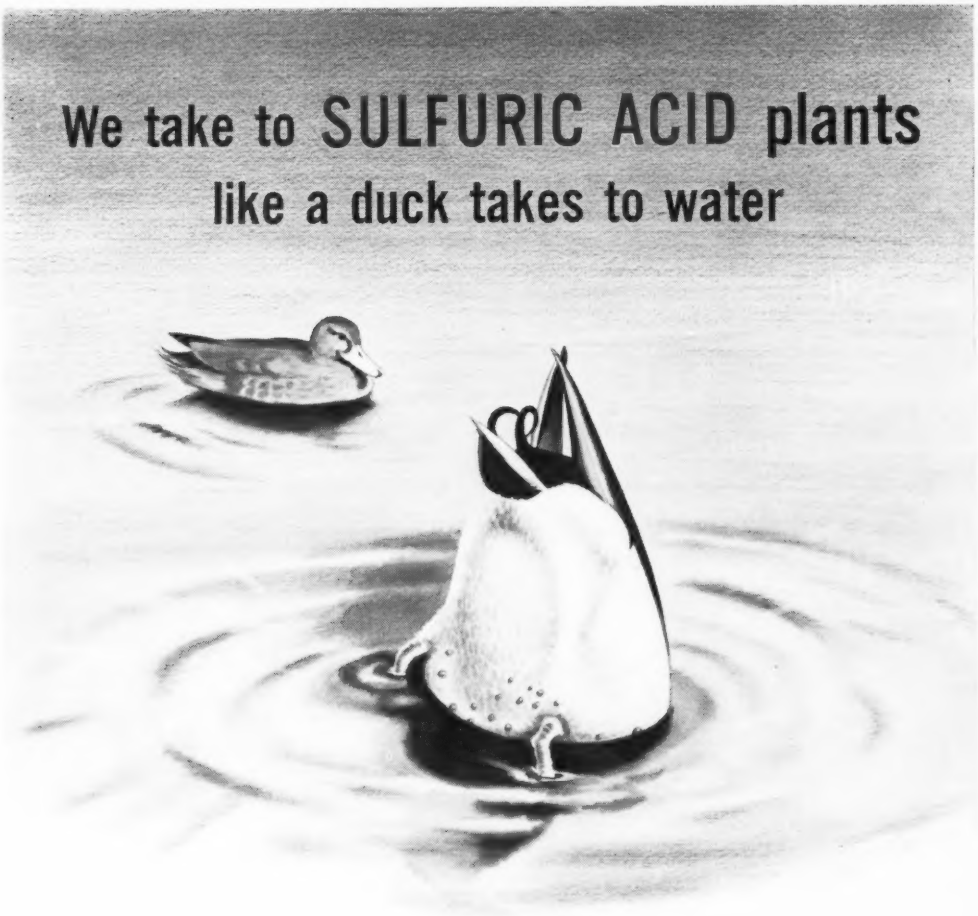

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Review

World sulphur prices have remained unchanged during the past three months but it is too early to refer to price stability, posted prices remain determined by the U.S. bright sulphur price of $25 per ton f.o.b./f.a.s., but in practice, "delivered" price quotations prevail, especially in competitive markets. European pyrites prices range from 57s. 6d. to 67s. 6d. per tonne f.o.b. Continued low ocean freights contribute towards cheap sulphur throughout the world.

World supplies have been aligned with demand, but 40-45% of Frasch sulphur capacity is unused. World stocks of brimstone are estimated at 5.8 million tons. New Frasch and recovered sulphur installations approaching completion are weakening the medium term statistical position.

An Outlook for the future of sulphur is provided by two leading executives of the sulphur industry, Mr. F. E. Lewis presenting the view point of a producer of sulphur recovered from natural gas in Western Canada, and Mr. O. Herneryd of a European pyrites producer of by-product pyrites. Their views, despite the wide differences in approach, coincide on several fundamental points, notably that sulphur in whatever form would find a market on economic merit and technical suitability, that the key problem of the industry was transport, that demand would expand rapidly and progressively and that a rise in sulphur prices was necessary to provide an incentive for further exploration and development of reserves. Looking to the medium term of 10-15 years their views emphasised the competitive force of by-product and recovered sulphur and underline the need in the interest of price stability to conserve sulphur resources.

In the United States production of sulphur in all forms in 1958 is estimated to have totalled 6.4 million tons, of which Frasch sulphur and recovered brimstone accounted for 5.26 million tons, 12½% less than in 1957. Industrial recession adversely affected domestic sulphur consumption and sulphuric acid output declined to 15.8 million short tons. Sulphur imports from Mexico exceeded 600,000 tons, whilst U.S. exports totalled 1.58 million tons.

In Mexico production of sulphur in 1958 totalled 1.27 million tons. Frasch sulphur exports, now Mexico's sixth largest foreign currency earner, amounted to 1.07 million tons, of which 57% were directed to the United States and 22% to Europe; they were supplied mainly by Pan American Sulphur Company. Domestic consumption, 91,000 tons in 1958, is expanding.

Recovered sulphur production in France, which in 1958 totalled about 140,000 tonnes, including 128,500 tonnes produced at Lacq from natural gas. Lacq brimstone production is now at an annual rate of 350,000 tonnes.

Elemental sulphur production in Japan of 180,000 tons in 1958 declined 30% on account of reduced demand by the viscose pulp industry. High sulphur mining and refining costs and imminent expansion of sulphur recovery are accentuating the need for new production methods, in this Matsuo Mining Company, Japan's largest sulphur producer, hope to achieve an early success.

In the United Kingdom consumption during 1958 of sulphurous raw material declined 5% to 1,078,000 tons, of which one-half was derived from indigenous sources, mainly anhydrite. The cost of 460,000 tons sulphur imported as brimstone and pyrites was the lowest since 1949. Low sulphuric acid consumption caused 4½% drop in production to 2.23 million tons (100% H_2SO_4).

Sulphur consumption in Australia in 1958 of 366,000 tons was the highest on record and about 50% of the industry's raw materials use was met from indigenous resources. Sulphuric acid output topped one million tons (100% H_2SO_4) to meet rising usage in fertilizer and metallurgical industries. The **new contact acid plant at Geelong** based on by-product H_2S and sludge acid from the adjacent Shell oil refinery is now on stream.

A Sulphuric Acid project at Europoort is to be based on by-product pyrites concentrates. This undertaking by Albatros Superfosfaatfabrieken N.V. and Cyprus Mines Corporation could help to emphasise the competitive status of pyrites in European markets.

An Outlook for World Sulphur

IN THE COURSE OF THE PAST SIX MONTHS the present and future world sulphur supply position has been examined in two important reviews, each focussing on different but equally important aspects of the world sulphur industry. In an address at Edmonton to a joint session of the Canadian Institute of Mining and Metallurgy and the American Institute of Mining and Metallurgical Engineers, Mr. F. E. Lewis, Vice-president of Jefferson Lake Petrochemicals of Canada Ltd., analysed the prospects of West Canadian sulphur in competition with existing supplies and the arising of increased supplies from established sources. In Stockholm, addressing a conference of Sweden's sulphur consumers, Mr. O. Herneryd, Sales Director of Bolidens Gruvaktiebolag examined the prospects of pyrites with particular reference to his own company's output of by-product flotation concentrates.

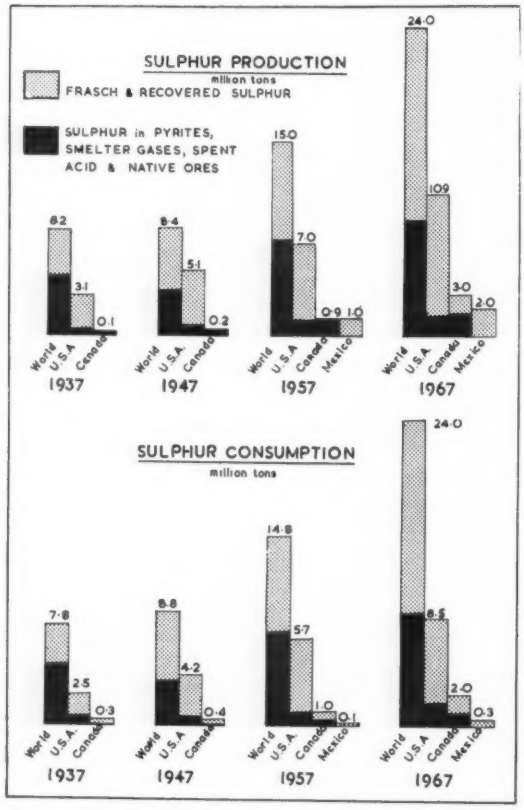


Fig. 1. Estimates of sulphur production and consumption. These graphs were shown in an earlier paper presented by Mr. Lewis.

Despite the different economic and geographical background against which these two industrial leaders projected their sulphur reviews and although from a commercial point of view they were competitors, both Mr. Lewis and Mr. Herneryd were agreed on three fundamental points. They emphasized that the industry did not face a Frasch sulphur problem or one of recovered sulphur or of pyrites but that sulphur, in whatever form it arose and entered the market, was judged and would find its outlet on grounds of economic merit and technical suitability. They both recognised that the key problem of sulphur was transport and that there is not in fact a surplus of Canadian recovered brimstone or of European pyrites, but, due to the circumscribed parochial markets, a pressure for economic outlets further afield. Lastly they both expressed confidence in the progressive expansion of world sulphur usage which, if it is to be met adequately in the long term, postulated the early advance of sulphur prices to levels above those ruling to-day as these were in many instances, barely remunerative and not conducive to development of existing reserves or the exploration for new resources.

Canadian Recovered Sulphur

"By 1961 brimstone recovery in Alberta and British Columbia would," Mr. Lewis opened his review by saying, "certainly account for at least 1½ million tons and probably more." Natural markets for Alberta sulphur, he pointed out, were essentially in Canada, United States and the Far East and Australasia. The North American Continent could be divided into seven main marketing

areas, as indicated in Fig. 2, of which three were of primary importance as outlets for Albertan recovered sulphur. By 1965 sulphur demand in the "Rocky Mountains," "Pacific North-West," and "Great Lakes," was expected

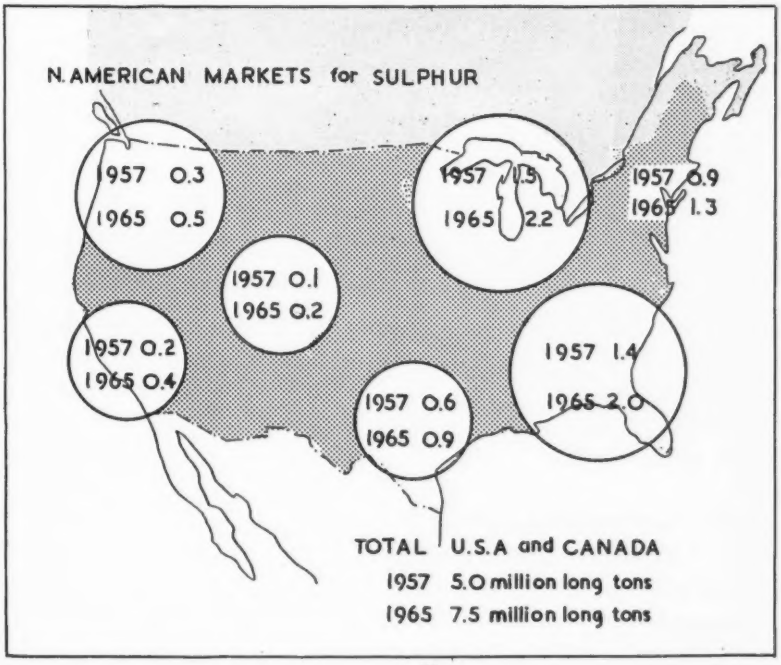


Fig. 2.

to expand by just over one-half to attain 2.9 million tons per annum. By extensive propaganda, endeavour had been made to focus the attention of Alberta producers on the local Pacific North-West and the Far Eastern overseas markets. This Mr. Lewis deprecated as he thought that the Great Lakes area was Alberta's best natural market and for this reason he felt that some detailed comment was warranted especially in view of Freeport Sulphur Company's concern over Albertan sulphur production and which resulted in their suggestion to the Alberta Conservation Board that the Westcoast Transmission Company's and Alberta Southern Gas Company's applications for natural gas exports to the U.S.A. be held up. Freeport's production of sulphur in the Gulf Coast, he said, is located near the Mississippi River, and over the years, they have acquired a dominant position in the Great Lakes market due to the freight advantage they enjoyed over their competitors. Also, this inland market has been protected from the inroads of competition from Mexican sulphur producers. Now, at a time when this company is spending $40 million to bring two new mines in the Gulf Coast into production with something like one and one-half million tons per year of additional sulphur production capacity, competition from Alberta sulphur rears its head here in the Great Lakes area. It is easy to see why they are concerned over Alberta sulphur, said Mr. Lewis. They not only want to hold on to the market they now have in this area, but would like to have the increase to take care of this $40 million investment.

Turning to export markets, Mr. Lewis stated there are to-day markets in Australia, New Zealand and the Far East for approximately 475,000 tons of elemental sulphur per year which by 1965 markets are calculated to grow to 900,000 tons per year. No sales to China have been shown in these estimates, and yet it is confidently felt that the opening up of the market in China is simply a matter of time. As the Chinese develop their industry, their demand for sulphur can exceed all the rest of the Far East market. Within this Far East and Western Pacific market area, the higher cost of transporting Alberta sulphur to the port as compared to the cost of transporting Gulf Coast sulphur to a port is offset by the shorter ocean mileages from Vancouver. From the Gulf Coast they have a longer ocean haul, plus the costs of moving through the Panama Canal or the Suez Canal. It is not expected that

Canadian sulphur will displace entirely sulphur from other producing points such as Mexico, the Gulf Coast and France, but certainly Canadian sulphur will find its way to a certain portion of this market and ultimately will enjoy a fair and just proportion of the sulphur sales within these areas.

The producers of sulphur in each of the geographical areas — Mexico, United States, Gulf Coast, France and Western Canada — have a primary market area where they have a distinct advantage on a delivered cost basis over their competitors. They have a second area where their transportation costs are essentially the same as the transportation costs of their competitors. Finally, they have a still further market that is determined by the amount of freight that they either can economically absorb or are willing to absorb.

Table I is designed to show the pattern of distribution of Canadian sulphur which Mr. Lewis expected to see in 1965:—

TABLE I

Market Estimates for Western Canadian Elemental Sulphur in 1965

—Thousand Long Tons

	Total Consumption	*Canadian Sulphur*	%
Pacific Northwest	500	500	100
Rocky Mountains	200	50	25
Great Lakes, Ontario & Mid-West	2,200	550	25
North Atlantic, Quebec & Maritimes	1,300	100	8
Far East, Australia, New Zealand	900	300	33
Total	5,100	1,500	29

Within the four areas—Rocky Mountains, Pacific North-West, Great Lakes, and the Far East—there is to-day a market for 2,400,000 tons of sulphur and in 1965 it is anticipated that there will be a total of 3,800,000 tons of sulphur consumed. It is foreseen that Canadian sulphur will fill all the need for sulphur in the Pacific North-West and a portion of the

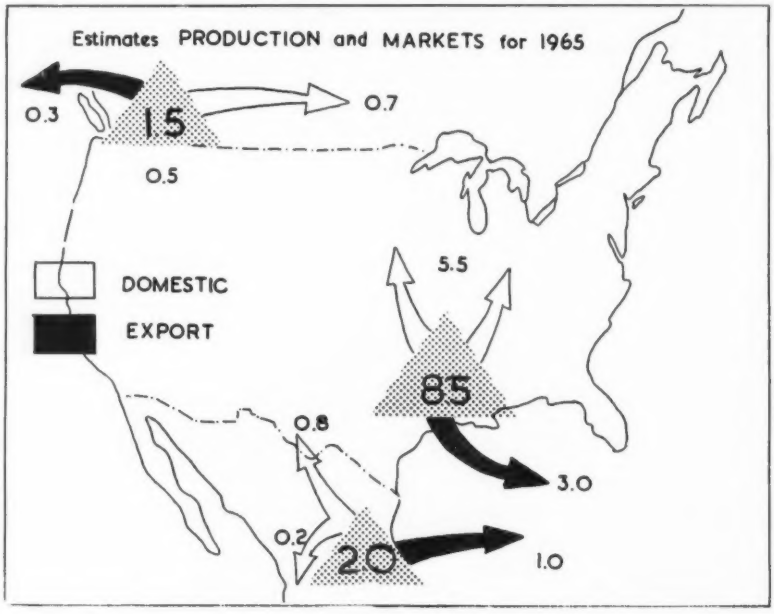


Fig 3.

requirements in the Rocky Mountain States. A production of 150,000 tons of sulphur annually in the Rocky Mountain States and a consumption of approximately 200,000 tons in 1965 is visualized. Due to proximity and lower freight rates from Alberta the difference will be made up by Canadian sulphur. Mr. Lewis outlined what he believed to be a constructive approach to selling Alberta sulphur. First, in the marketing areas, the advantages of having a nearby source of Alberta sulphur that can be delivered more rapidly than sulphur from the Gulf Coast must be emphasized. This reduces the amount of inventory the consumer must carry—it means better service. Secondly the Alberta sulphur producers must plan on carrying substantial inventories at strategic locations for ready distribution to serve their customers promptly and adequately. There is nothing novel in this idea to those who have been engaged in the sulphur industry in the past, and the new producers will obviously

follow this same pattern for competitive reasons. Thirdly, they must all follow good selling practices, basing their sales approach on quality service and dependability—not on price-cutting as a method of obtaining sales. This means a sales force of top quality men will be required and more sales calls must be made. Last, but by no means least, the established Frasch sulphur producers must face up to the fact that this Alberta sulphur is coming into the market as a co-product of the natural gas industry, and that they will have to live with it. It might even mean that sales of Frasch process sulphur will be reduced temporarily. Mr. Lewis said that his parent company was one of the Frasch process producers and that they recognised that fact. It was also recognised that any attempt to meet the problem by cutting prices will only lead to wiping out the profits of the Frasch producers and will accomplish absolutely nothing except the closing down of the small sulphur mines—the total production of which is not over twenty per cent of the expected Alberta production. Obviously, price-cutting to meet the competition of Alberta sulphur would bring nothing but disaster to the Frasch sulphur mining industry, because the Frasch producers would not only have the problem still with them, but would have to cut their profits essentially to nothing.

With world-wide demand for sulphur forecast at twenty-four million tons in all forms by 1967, of which approximately fourteen million tons is estimated as elemental sulphur demand, Mr. Lewis could see no long-range problem for the sulphur industry. With the present market for Canadian sulphur depicted in the four marketing areas which have been examined and the growth forecast in those marketing areas within the next seven years, he continued, there should be no basic problems for the Alberta sulphur producer.

Sulphur in Europe

The assessment of the future, as seen by the European pyrites industry, is made by Mr. Herneryd against the background of Europe's sources of pyrites and brimstone supply, the development in the 1950's and an outline of the 1956 consumption, when, of Europe's usage of 5.8 million tons sulphur, more than half (59%) has derived from pyrites, 23% from elemental sulphur and the other 18% from other sources. Only one-seventh of the whole demand for sulphur had to be imported, mainly as brimstone. European, like world demand for sulphur, Mr. Herneryd said, was determined by the need for sulphuric acid manufacture which accounted for as much as 80% to 85% of the world's sulphur production. The trend of the production of sulphuric acid, therefore, should give a good indication of how the total sulphur consumption of the world has developed. Fig. 4 shows the world production of sulphuric acid since the 1880's, indicating that production appears to have increased almost rectilinearly, at an average rate of about 4%. If it is assumed that the tendency during the coming decades will follow this trend, the world consumption of sulphuric

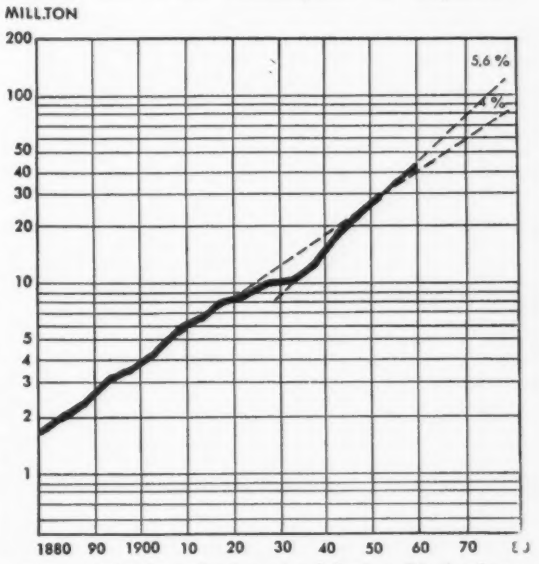


Fig. 4. World production of sulphuric acid showing the trend lines of an average annual increase of 4.0% and 5.6%.

acid, Mr. Herneryd pointed out, will be doubled in eighteen years. This is equal to an increase in the demand for sulphur of 16 million tons. The growth of consumption during the past twenty years, however, has been greater than 4% and, if this higher rate of increase continued, consumption would be doubled in thirteen years. In leading producer circles in the United States it is estimated that world consumption will be three times as great

in twenty-five years, which is equivalent to an annual increase of about 4.7%. Mr. Herneryd accepted that these figures seem very high at first glance, but expressed as a per capita sulphur consumption, it will be found that at present it is at a world average of about 13lbs. European consumption amounts to 44lbs., and that of the U.S.A. 77lbs. In Sweden it is as high as 93lbs. Only a slight rise in the per capita consumption in under-developed countries would imply a great increase in the demand for sulphur and pyrites. Above all, greater fertilizer consumption to meet the conditions created by mounting population pressure and new uses, such as uranium ore treatment, were adding to the expanding sulphur requirements of established consumer industries. Turning from the broader picture of world supply, which was much affected by the new recovered sulphur production in France and Canada and the prospect of greater output from the Frasch sulphur domes of the United States and Mexico, Mr. Herneryd centred his attention on Europe. As indicated

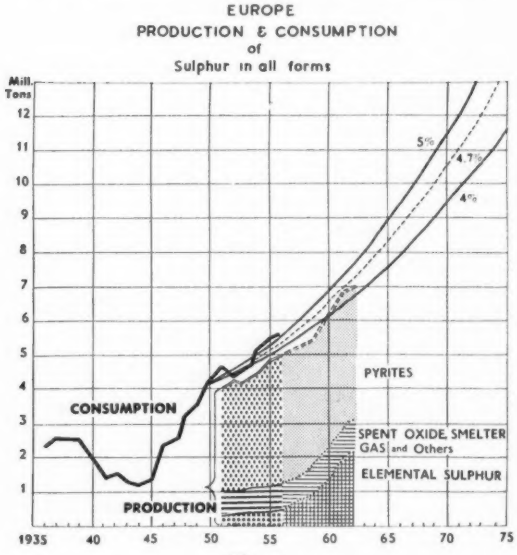


Fig. 5.

in Fig. 5 European sulphur consumption since 1950 has grown at a rate equal to almost exactly 5% per annum and if projected at 4%-5% per annum to 1962, Europe would need $6\frac{3}{4}$-$7\frac{1}{2}$ million tons sulphur as against 5.8 million in 1956. There is a gap between supply and demand, met by imports which in 1957 totalled 0.8 million tons. The anticipated European production of elemental sulphur, as shown by the steep rise of the graph in Fig. 5, is mainly represented by Lacq, but also by the brimstone recovered at oil refineries. If it is assumed that consumption rises at the rate of 4% per annum, the whole of the Lacq production would be absorbed by the growing consumption at the same rate as it appeared, but only on condition that imports from America diminished, and ceased in 1961. Up to 1975, however, a further 4 million tons of sulphur would be required, and it is unlikely that the French deposits would be able to increase their contribution. This greater consumption would therefore have to be covered by increased imports from America, or, what is most probable, by a higher consumption of European pyrites. If the trend of consumption followed the 5% curve, however, French production would be absorbed even if the imports of sulphur from America remain on the whole unchanged. The scope for an increased consumption of pyrites or further imports of American sulphur would in that case still be greater.

Keener competition is the corollary and Lacq sulphur, being a by-product capable of being produced at very low cost and having also the advantage of a better geographical situation with lower costs of transportation to European consumers, is likely to replace gradually imports from the United States and Mexico. In assessing the capacity of pyrites to compete, Mr. Herneryd expressed the view that the manufacture of copper, lead and zinc will be based more and more on sulphide ores poor in metal, which must be passed through a flotation process before the metal can be extracted and in the course of this flotation pyrite concentrates will always be obtained. It must be presumed, therefore, that the production of flotation concentrates will increase and will find its way into the world market. The possibilities of pyrites competing with elemental sulphur need, quantitatively, cause no problem. Nor has there ever been any lack of pyrites but only insufficient capacity at the mines when attempts have been made

to satisfy a sudden demand. As regards price, pyrites have every possibility of asserting themselves. It is therefore probable that the future increase in consumption will be covered by pyrites, that is, pyrites will retain or increase their relatively great share in Europe's supply. This, Mr. Herneryd emphasised, only held on condition that the price relation between sulphur and pyrites is kept realistic.

Views on the Price of Sulphur

Since American production dominates the world market, and will do so for a very long time to come, it will be the American price that

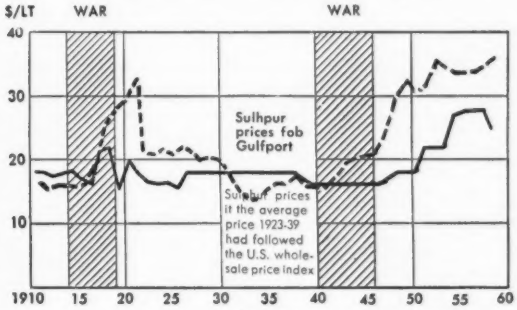


Fig. 6.

will decide the world price level for sulphur. Current low prices are held to be responsible for the lack of incentive, on the part of several of the great Frasch sulphur producers, to explore and develop new deposits as the result of which it is possible that the U.S. sulphur Companies may be in a weak position should, in the 1960's, sulphur demand surge ahead. A study of the balance sheets of the great sulphur companies shows that the margin between costs and receipts seems at present to be inadequate. In view of this and unanimous official announcements from America, one is justified in regarding the current price of $25 what might be called as being below a normal sulphur price. Even a return to the price prevailing before the latest reduction, $28, would probably be insufficient. There are a number of modern plants capable of producing at prices far below this level but there are other up-to-date plants working at unfavourable conditions. It is a well-known fact that it is not the cheapest unit of production that decides the market price but the last necessary contribution to production that is required to satisfy the demand. As the demand for sulphur will increase greatly, it will, in the long run, be the new, more costly deposits that will determine the development of market prices. Expressing the view that the price of American sulphur would soon reach the $28 level, Mr. Herneryd thought that still higher prices were possible as soon as the present slump was over and that he already discerned a rising price tendency in the United States. More than the U.S. price level, the factor determining European sulphur prices, however, is the state of the freight market. The severe fluctuation of recent years culminating in peak freights during the Korean War and again during the Suez crises and the freight slump which has depressed rates progressively since early in 1957, have made it difficult to determine a "normal" freight from the Gulf of Mexico to Europe, although Mr. Herneryd voicing a widely accepted figure suggests this to be 60s. Thus "normal" continental c.i.f. sulphur price on the basis of $28 would be $36.40 (£13) per long ton. Since Mr. Herneryd relates this price—which equals about Sw.Kr.185—to Swedish conditions which demand delivery in lots smaller than 10,000 tons in Baltic ports, he augments it by Sw.Kr. 10 and comments: "Prices below that figure must be regarded as low, and the current market price, 165-170 crowns*, as very low. On the other hand, these views on prices do not imply that the price of sulphur will be fixed at 195 crowns, but only that 195 crowns will probably be the mean price around which the price will fluctuate, assuming that the general level of prices otherwise remains unchanged."

Examining the relation between brimstone and pyrites Mr. Herneryd illustrates it by pointing to the end-1958 position in Sweden which shows that the price of pyrites is determined by the market situation of elemental sulphur and the price of residues. In addition, naturally, the situation on the freight market plays an important role. The influence of these factors on each other is complicated but the picture becomes simpler if the price of pyrites is estimated on the basis of the sulphur content, after the pyrites have been credited with the value of the residues and after allowing for the cost of transportation to the roasting plant.

* Since then Swedish delivered prices have declined to Sw. Kr. 158.

* 100 Swedish Kroner equivalent to £6 18s. or $19.20.

Brimstone		*Pyrites*	
f.o.b. U.S. Gulf		Sw. Kr. 70	per metric ton f.o.b. Rönnskär basis 48%
Gulf $25 ...	Sw. Kr. 128		
Freight	Sw. Kr. 37	Sw. Kr. 9	freight to Swedish E. Coast Port
	Sw. Kr. 165	Sw. Kr. 79	Basis 48% S.
		Sw. Kr. 164	c. & f. per ton S. contained allowing for Bolidens 50% S.
		less Sw. Kr. 57	for residues*
		Sw. Kr. 107	

Having determined the net sulphur value of pyrites at Sw.Kr. 58 below that of brimstone and the need for this due to higher

	*Modern Sulphur Plant**	*Modern Pyrites Plant**
	Sw. Krs. per ton sulphur in gas	
Capital costs, 10 years — 7 per cent	11:	25:
running costs	10:	17:
Total	21:	42:
Credit for Steam (12 Sw. Kr./ton steam)	24:	38:
	−3:	+4:
Raw Materials Costs per ton Sulphur	165:	107:
Losses of Sulphur in Residues	—	2:
Total Costs per ton Sulphur in Gas	162:	113:
		difference 49:

* Capacity 25 tons sulphur/day.

production cost of pyrites acid, Mr. Herneryd comments on this cost estimate as follows:

The estimate refers to ideal plants and the price difference on a "sulphur only" basis between sulphur in pyrites and elemental sulphur is Sw. Kr. 58. If the loss of sulphur in the residues, Sw. Kr. 2, is taken into consideration the difference is reduced to Sw. Kr. 56. The total cost of one ton of sulphur in gas is thus Sw. Kr. 49 lower for pyrites than for sulphur. At existing plants with good transport facilities pyrites are usually even more favourable.

In examining the sales prices of his company's F-quality pyrites, which are used mainly in flash roasters, he stated that the margin based on the above calculation in the past 10 years never fell below Sw. Kr. 50, and at the time of the Korean boom when brimstone prices boomed, amounted to several hundred crowns. His company's aim was to maintain a margin and at the same time reasonably stable prices which, under conditions of low brimstone prices, would tend to narrow the margin and vice-versa. Pyrites residues would continue to hold a key position in determining pyrites, and to this end Bolidens intended continuing their present policy of assuming responsibily for their customers' residue sales, which were at present sold under long-term contracts to the German iron masters, and sell pyrites on the basis of "sulphur only."

Conclusion

The views of these two responsible top executives of the sulphur industry are of necessity coloured by their companies' specific problems and although they tend to attach the main emphasis to favourable aspects of their respective cases, they provide pointers of considerable weight to indicate which way the producers would expect the price and supply pendulum to swing. Perhaps the outstanding feature in the producers repeated expressions of alarm about the current low prices and the possibility of a sulphur shortage in the not too distant future, is the realisation that price-cutting—whether the last resort of the newcomer in forcing his way into market or a final attempt by the established supplier to ward off competition—has failed so far to augment sulphur demand by a single ton. This would tend to add substance to the expectation of higher prices but in the absence of an understanding between the various producer groups, which the Webb-Pomerene Act prevents by outlawing any U.S. producer contemplating such a step, the criterion remains the weight of sulphur supplies in various forms against the volume of diversity of world wide demand.

Both Mr. Lewis and Mr. Herneryd in common with all sulphur producers understandably base their case on reasoned precedent, statistical trends and extrapolations—the table showing the growth of sulphuric acid production is a good example. It would be possible to modify or even discount the customary growth of sulphur demand by selecting contraversial features in the development of the major consuming industries, such as the respective rates of growth of fertilisers requiring large or small quantities of sulphur in their manufacture, or the duration and

* Sw. Kr. 42 per ton residues; 0.65 tons residues per metric ton pyrites; 2.08 tons pyrites per metric ton of sulphur.

extent of fluctuations of the prosperity in important sulphur using industries, such as viscose rayon. Such arguments, however, tend to focus on short term phenomena whereas the essential factor in these considerations is the growing impact of sulphur recovery.

Alberta sulphur and Bolidens flotation pyrites are both by-products recovered in the course of the principal—whether gas or metal production—operation and with justification Mr. Lewis and Mr. Herneryd, while focussing attention on expectations of greater sulphur demand, extol the ability of their secondary products to remain competitive. What of the primary sulphur producers at the Frasch domes of Mexico and the United States Gulf Coast and at the pyrites mines of Spain, Norway and Portugal? Mr. Lewis in this respect referred to the need for primary producers to conserve their resources and exploit them more fully only when markets warrant it. This viewpoint gives a reasoned and acceptable outline of the medium term development in sulphur markets; it is one which the industry, as a whole, cannot afford to disregard during the next 10 to 15 years. The growth of consumption will be determined in the West by the maintenance of cheap sulphur to give sulphuric acid and other derivatives the biggest scope for expansion in existing and into new fields. In the East, however, the economic considerations are not overriding and comparative ease of operation of or the efficiency of products based on other than sulphur-based processes may carry greater weight.

It is perhaps significant that greater anxiety about prices is expressed by Mr. Lewis who is in very close touch with and conscious of the problems of the Frasch sulphur producers, whereas Mr. Herneryd, in common with the majority of pyrites producers, now appears to be fully reconciled to the need for pyrites to remain competitive and this, in view of their iron value and perhaps of some geographical advantages in Europe, is feasible. Clearly the critical and decisive factor is timing and just as the onset of price reductions in the autumn of 1957 was ill-timed, anticipating the need by nearly three years, the danger remains that over-emphasis of past strength or expectations of future market dominance may perpetuate price cutting beyond economic limits and to the long-term detriment of the entire industry.

Recovered sulphur at Jumping Pound, Alberta.

Prices and Trends

THE WORLD SULPHUR supply situation remained substantially unchanged during the past three months and the unremitting pressure on prices which had been evident throughout 1958 has tended to slacken mainly due to restraint on the part of sellers of Mexican sulphur and the early disposal of the French export surplus. In Europe and Eastern United States sulphur markets, where competition has been and still is most intense, it is still a far cry from price stability and the threat of cuts in "delivered" prices has not been removed. The tone of the market is set by the sales policy of Sulexco.

During 1958 the activities of the world sulphur industry contracted under the influence of recession or stagnation in industrial production in the United States and most European countries. A year of weak sulphur markets and receding prices for brimstone and pyrites, it lacked new developments strong enough to arrest these trends. The most disquietening feature of the early part of the year was undoubtedly the progressive erosion of the price basis and the consequent damage to consumers confidence in stability. Later a number of corrective features emerged which set the tenor for the current year. Thus the improvement of the short term statistical position may be attributed to the reduction of the level of U.S. Frasch sulphur production and concurrent reduction in stocks and to the restraint of Mexican producers. Both sectors of the Frasch sulphur industry are estimated to employ only between 55% and 60% of the installed capacity, now nearly 10 million tons per annum. Simultaneously the two leading United States and Mexican producers, Texas Gulf Sulphur Company and Pan American Sulphur Company, both decided on installing major liquid and dry sulphur storage facilities in Tampa, Florida, in a bid to improve their customer service in this important and growing consumer area, which is probably the most concentrated fertilizer producing and sulphur using area in the world. In this connection Texas Gulf Sulphur Company's apparent success with ocean-going liquid sulphur transport facilities could represent a telling advantage in the prevailing competitive world markets.

Of particular interest to the European sulphur industry are the measures taken in the pyrites sector, which, after several years of failure to resist the competitive impact of brimstone, now aims to regain the initiative in its traditional markets. Its armoury is impressive in that the price of sulphur in pyrites has been reduced to competitive levels; transport costs are at present low, and the availability in fluidised bed roasters and the newly-developed hearth furnaces, with steam recovery, eliminates much of the disadvantage in operating cost. Standing at the focal centre of these developments is Duisburger Kupferhütte, whose firm measures in respect of residues disposal have helped to consolidate the position despite the 20% reduction in residues values which followed the general decline of iron ore prices in Europe.

Of potentially far-reaching influence is the decision of a major pyrites producer—Cyprus Mines Corporation—to enter into a joint venture with a consumer -- Albatros Superfosfaat Fabrieken — sharing the heavy capital expenditure for the pyrites acid plant whilst at the same time securing a permanent sales outlet.

These developments in the Frasch sulphur and pyrites sectors of the world sulphur industry are part of endeavours to secure positions of advantage in the period 1960-1963 when the full weight of existing sulphur recovery projects will affect the world supplies at a time when it is doubtful whether demand will have advanced enough from the present low levels to prevent a serious deterioration of prices. Recovered sulphur output from the three main sources, U.S.A., Canada and France, is expected, on the basis of installed recovery capacity and planned operations, to total 1.8 million tons in 1960 and rise to over 4 million tons by 1963. In addition, recovery operations from gases arising in oil refining, coal gasification and metal smelting are expanding throughout the world and their impact—in terms of at least 120,000 tons per annum new recovered sulphur production in

various forms—is a key factor in determining the nett growth of the sulphur demand which is left to be met by conventional suppliers.

PRICES

Brimstone

The posted domestic and export prices of United States Frasch sulphur remain unchanged at $25 per long ton f.o.b./f.a.s. U.S. Gulf Ports for bright material. Producers selling off-colour material continue posting this grade at a discount of $1 per ton, whereas all deliveries ex-mine enjoy a discount of $1.50 below the respective f.o.b./f.a.s. price of the appropriate grade. In the more competitive markets the practice of quoting on the basis of delivered terms is now well-established both with home and export sales and such quotations often incorporate disguised discounts, or freight rebates. At home United States Frasch sulphur is meeting most severe competition on the Eastern Seaboard from Mexican imports and domestic recovered brimstone. Currently delivered prices range from $25-$28 per ton. In the Mississippi Valley and the Western United States much firmer price levels prevail. The price policy of the Sulphur Export Corporation remains intent on securing an increasing volume of business for its four principals. In most North-West European markets delivered prices of $26.50 to $28.50 are reported ; in Eastern Canada and South Africa United States sulphur is landed at about $31.

Prices of Mexican Frasch sulphur continue unchanged at $23.50 per ton f.o.b. Coatzacoalcos for fully filtered yellow material. Off-colour and unfiltered material, of which only limited quantities are entering world markets, is sold at prices ranging down to $20.50 per ton f.o.b. Exports of Mexican sulphur to the U.S.A. made in vessels other than those of United States Flag, which are tarriff-bound, enjoy a freight advantage of $2-$2.50 per ton. This advantage enhances the already low cost of freight to customers and more significantly to Mexican sulphur stockpiles in Florida and on the Atlantic Seaboard.

Based on the delivered prices of United States and Mexican sulphur the sales price of indigenous recovered sulphur productions has remained relatively stable, this applies in particular to the growing volume of sales by the Société Nationale des Pétroles d'Aquitaine. In Western Germany the internal price of brimstone—from spent oxide by Ruhrgas A.G. and at oil refineries—is quoted in the range of D.M.118-128 per tonne. In Belgium recovered sulphur is sold at B.Frs. 1,500 per tonne and in Holland at D.Fl. 110. Reduced demand by the pulp industry in Scandinavia and severe competition by all major suppliers has depressed domestic prices to Skr. 158-164. Orkla Metal A./S. is reported to have made corresponding adjustments to the price of their recovered brimstone output. In Western Canada the price to domestic consumers is at present $23-25 f.o.r. recovery plant and on the basis of this price it appears that recovered sulphur is competitive throughout North-West Canada and N.W. United States. Pending a satisfactory determination of rail rates it is reported that Alberta producers have refrained from quoting an export price f.o.b. Vancouver which, in order to be competitive in world markets, would have to correspond with export prices ruling at Gulf ports.

The following table indicates broadly the delivered cost of brimstone of varying origin at principal consumers' destination based on posted and ruling freight rates. The rates shown are either actual charters made at the end of March or reliable indications.

f.o.b. Country of origin	*U.K.*		*N.W. Europe*		*France (Mediterranean)*		*India*		*Australia*	
U.S.A. $24-25 ...	(45s.)	£10¼-11½	(37s. 6d.)	£10½-10⅞	(45s.)	£10¼-11½	(80s.)	£12½-12⅞	(65s.)	£11½-12½
Mexico $20.50-24	(45s.)	£9½-10¾	(37s. 6d.)	£9⅝-10½	(45s.)	£9½-10¾	(80s.)	£11¼-12½	(65s.)	£10½-11¾
Italy Lire 23,000*	(30s.)	£14⅞	(25s.)	£14⅝	(22s.)	£14½	(50s.)	£15⅞	—	—
Canada $23-50 ...	(60s.)	£11⅛	(55s.)	£11⅛	(55s.)	£11⅞	(70s.)	£11⅞	(60s.)	£11⅛

Freight indications ( ) have been reduced to f.i.o. terms to provide a common basis for comparison. *Per metric ton.

Pyrites

The export price level which the European pyrites producers established with effect from 1st January, 1959, and which apply to sales for the first half-year, has not undergone any

significant changes. Rio Tinto and Tharsis crude fines pyrites are quoted at 67s. 6d. per tonne basis 48% S. f.o.b. Huelva and the lesser Spanish producers selling in export markets base their prices on this quotation. Rio Tinto confines, when available, is now quoted at 57s. 6d. Cyprus Mines Corporation's flotation concentrates continue being quoted at keenly competitive prices and, although their impact on foreign markets is much smaller, so are Bolidens flotation concentrates. Portuguese pyrites are quoted in export markets at 65s. The outstanding price change in pyrites occurred in January when the domestic controlled price in Spain was increased by nearly 40% from Pesetas 266.80 to Ptas. 370 per tonne basis 48% S. This increase much improves the economics of several Spanish pyrites mining operations and the level of domestic sales is now such that a high internal price could readily balance price "concession" in export markets if this became necessary.

Freights

In the absence of relief from the heavy pressure of laid-up tonnage, at present about 7% of the world's dry cargo fleet, or of full employment of the growing volume of modern vessels coming off the stocks, freight rates have continued to decline. The volume of seaborne trade remains low mainly owing to reduced commodity shipments such as coal and grain, although there are some expectations of a modest improvement in respect of the latter. Reflecting the weakness of the markets, the Voyage Index of the United Kingdom Chamber of Shipping (1952=100), which at the end of December stood at 74.6, has further declined to 65.1. Transatlantic freight rates for sulphur from the United States and Mexican Gulf ports to Continental ports are currently at a level of about $4.50-$5.00 for 9,000/10,000-ton vessels whereas larger vessels have been secured for less. To the United Kingdom, spot charters at 45s. have been reported.

Heavy shipments to South America (Atlantic Ports) are reflected in keen quotations by liners and charters, and U.S. Gulf to Brazil at $5 is evidently the basic rate. An economic charter from Coatzacoalcos to Callao provides a valuable pointer for future trade with the Pacific Coast countries of South America. European freight rates remain low and pyrites from Huelva to N.W. European ports are regularly quoted at 22s. 6d. and 25s. 6d. from Cyprus for 8,000-ton vessels. The prospect of low requisitions during the forthcoming months adds to the depression of this section of the market in which the new production of Lacq sulphur to be shipped from Bayonne offers one of the few consolations. From Bayonne, now regularly served by up to 5,000 tons vessels and where the new sulphur loading installations are due to be officially opened in May to N.W. European ports, sulphur is quoted at 16s., and to the United Kingdom at rates ranging from 23s. to 29s., depending on the accessibility and discharge facilities of the many small ports through which Lacq sulphur now serves several of its U.K. customers.

SUPPLIES

In the United States, Frasch sulphur producers continue to curb output which has not advanced significantly from the end-1958 level of 380,000 tons per month. Although less than expected, domestic demand has improved and stock levels have receded to about $4\frac{1}{2}$ million tons after reaching $4\frac{3}{4}$ million tons in mid-1958. Imports of Mexican brimstone have risen to a monthly rate of 60,000 tons, and with domestic recovered sulphur at about the same level of production these two sources account for at least 25% and often 30% of United States current domestic brimstone use.

In Mexico, output of Frasch sulphur averages nearly 100,000 tons per month, of which at least two-thirds is provided by Pan American Sulphur Company. Whilst Texas Gulf Sulphur Company maintains the level of output at a monthly rate of 10,000 tons, Gulf Sulphur Corporation is pressing forward a regular output level of 900-1,000 tons per day. Despite some fluctuations in export shipments, the volume has kept up to the satisfaction of the two companies, Pan American and Gulf Sulphur, concerned. Mexican Frasch sulphur stocks, despite Texas Gulf Sulphur Company's continued policy to stockpile the entire output at Nopalapa, have risen only modestly and are estimated at about 900,000 tons.

In Japan the level of output, which in 1958 averaged 15,000 tons monthly—40% less than the peak production early in 1957—remains adversely influenced by reduced demand from its main customers, the rayon and pulp industries. In Italy output of fused sulphur in 1958 totalled 157,580 tonnes. Production is progressively being restricted and in recent months ranged from 5,000-13,000 tonnes per month. The severe reduction of exports to less than 10,000 tons during the second half of 1958 and fluctuating domestic demand is adding to stocks which on 31st December totalled 233,300 tonnes. The future of the sulphur mining industry on the mainland and in Sicily is being saved by the rapid expansion of sulphuric acid capacity based on ore. By the end of this year consumption of sulphur ore is expected to exceed an annual rate of 600,000 tonnes, which is double that of 1957. Production of refined sulphur in South America has declined heavily and in Colombia, Peru and Bolivia it is reduced to token quantities measured in tens or hundred tons. In Chile, employing about one-quarter of available refining capacity-output in 1958 was about 25,000 tons. In the Argentine the start in November by SOMINAR S.A. after many years of preparation and development of a Chemical Construction Corporation sulphur ore flotation and refining plant, will increase domestic brimstone production by about 10,000 tons to reach 45,000 tons.

Recovery

In the United States the level of sulphur recovery has increased spectacularly as the result of new plant capacity coming on stream the current output is at a monthly rate of over 60,000 tons. Canada's recovered sulphur output of about 203,000 S. tons during 1958 was, as expected, only a little greater than in the preceding year. The recent completion of new plant, notably at Fort St. John, Pincher Creek and Okotoks has brought effective production capacity to over 600,000 tons per annum. A contribution towards solving the problem of high transport costs, from the recovery plants in Alberta to the major consuming centres near the Great Lakes and the Pacific Coast, is the proposed construction of a sulphur pipeline by Foothills Pipe Lines. A bill incorporating a company with a capital of $50 million is about to be passed by Canada's Parliament. In France at the Lacq natural gas field the daily rate of recovery has risen to about 1,000 tons now that the second stage of the development has been in full operation since December. Oil refinery activity throughout Europe was in recent months maintained at a high level and correspondingly sulphur recovery grew to the estimated rate of about 15,000 tons monthly. Overseas as well, as indicated by the developments in Australia at the Shell (Geelong) and the Vacuum Oil (Altona) refineries and in the Union of South Africa at the Standard Vacuum Refining Co. of South Africa (Pty.) Limited's Durban refinery, the oil industry is making notable contributions towards indigenous sulphur supply.

Pyrites

The outstanding feature in the European pyrites picture is the continued high level of activities of the Cyprus Mines Corporation, whose output for the third consecutive year has been a record. In the declining market prevailing in 1958 the significant growth of Cypriot pyrite sales and the favourable results of the Portuguese pyrite producers are in contrast with the difficulties encountered by Spanish pyrites, whose output is reported to have receded 20%, and to a lesser extent by those of Norway. By-product pyrite concentrates of the St. Patricks Copper Mines of Eire are slow in finding markets and only a modest tonnage has so far entered the United Kingdom. In Canada the closure on economic grounds of the Noranda sulphur/iron plant at Port Robinson has narrowed the pyrites market and dashed for the present the prospects of extending the application of this process in Eastern Canada. In Southern Rhodesia following the start of activities of the African Explosives & Chemical Industries' Rhodia plant near Salisbury output at the Iron Duke mines at Glendale has increased. Similar developments of indigenous overseas pyrites resources being used for fertilizer manufacture are reported from Cuba and Venezuela, whilst in India plans are being advanced for the use of indigenous pyrite resources in the recovery of elemental sulphur by the Orkla process.

UNITED STATES SULPHUR

Frasch Sulphur

Production of Frasch sulphur in 1958, totalling 4,644,812 tons, was, as the result of further restrictions on output by the producers to bring it into line with demand, 846,400 tons (15%) less than in 1957. As shown in Fig. 7, monthly production continued to decline from 461,300 tons in January until in September at 335,800 tons the lowest level for some years was recorded.

Although during the last four months of the year production rose slightly to reach 378,000 tons in December—only 9,000 tons short of the monthly average during 1958—producers did not expand their activities as much as the improving level of sales might have warranted but instead withdrew modest tonnages from stocks. At the end of 1958 the level of stocks had declined to 4,442,066 tons, almost the same level as at the beginning of the year, although at the end of July, they had reached the high total of 4,721,167 tons. United States Frasch sulphur production in 1958 originated from twelve domes, eleven of which were active throughout the year whereas the twelfth, Fannett Dome of Texas Gulf Sulphur Company, came on stream in July.

The following table, based on preliminary data, indicates the level of activities by individual Frasch sulphur producers.

	1958	*1957*	*Change*
	Thousand tons		
Texas Gulf Sulphur Company	2,126	2,866	– 26%
Freeport Sulphur Company	1,976	2,039	– 3%
Jefferson Lake Sulphur Company	395	431	– 8%
Duval Sulphur & Potash Company	148	153	– 3%
TOTAL:	4,645	5,491	– 15%

Texas Gulf Sulphur Company. It is evident from the above table that Texas Gulf Sulphur Company bore the brunt of the cutback of United States sulphur production. Operations at Boling dome which yielded about 1¼ million tons are reported to have been reduced to the lowest level compatible with the efficient maintenance of installations and the future reactivation of this unique source of production. Activities at the company's other two established domes, Moss Bluff and Spindletop, were not reduced as drastically, mainly because the company's lease and royalties arrangements necessitated the maintenance of an adequate level of operations. Notwithstanding the reduced rate of deliveries the company decided towards the end of the year to carry out the major reconstruction programme ($3million) of the shipping facilities on the Neches River, south of Beaumont to serve Spindletop and also the new Fannett plant which is only 15 miles distant. Fannett dome, the latest addition to the company's production facilities which came on stream in July 1958 is reported to have produced regularly since then at a daily rate of about 1,000 tons. The boiler plant and ancillary installations appear to be giving faultless service and the output of the new dome is reported to be bright yellow.

Freeport Sulphur Company: The Company's ability to maintain production near the output level of the preceding year has brought its level of operations almost up to that of the world's premier producer, although the company's two main domes, Grand Ecaille and Garden Island Bay, operated well below their capacities. In this connection it is well to recall that Freeport's lease arrangements deprive the company of some flexibility in the determination of the level of operation.

Duval Sulphur & Potash Company and *Jefferson Lake Sulphur Company* both kept up the level of operations of their ageing dome properties near capacity levels, principally because their modest size necessitates this for reasons of operating economy.

Recovered Sulphur

During 1958 production of recovered sulphur expanded yet again and at 619,594 was 100,500 tons (19⅓%) greater than in 1957. This notable increase is the result of a large number ot plants coming on stream in late 1957 and during 1958 and it is estimated that the addition of new plants augments the installed capacity of recovered sulphur by approximately 125,000 tons. Prominent amongst new installations is the 70 tons per day expansion by

Consolidated Chemical Industry Inc., of their recovery unit based on H_2S from the adjacent Baytown oil refinery. Also a 70 tons per day plant based on oil refinery H_2S was installed by Foster Wheeler Corporation at Beaumont for Magnolia Petroleum, whilst at Cottonwood Creek, Wyoming, sour natural gas cleaning provides H_2S for a new 25 tons per day plant of Pan-American Petroleum Corporation who now have an aggregate daily recovery capacity of 176 tons at five plants.

Other Sulphurous Raw Materials

Despite the several adverse features affecting the level of United States sulphur activities, the production and usage of sulphur other than brimstone does not appear to have changed appreciably. Total output of such sulphurous raw materials is estimated to have been 1,120,000 tons, a modest increase of under 4%. Low grade sulphur ore and pyrites production and usage remained at the previous year's levels whilst by-product sulphuric acid from metal smelters and the use of oil refinery sludge for conversion to sulphuric acid, increased slightly accounting for the expansion of this sector of the industry.

	Thousand tons	
Sulphur in:	*1958*	*1957*
Low Grade sulphur Ore	50	50
Pyrite & Pyrrhotite	400	400
Smelter gas as sulphuric acid ...	300	280
H_2S & sludge to sulphuric acid	370	350
TOTAL:	1,080	1,120

Exports

The level of United States exports was not only maintained but, in the face of increasing competition from Mexican and French supplies, rose 17,800 tons (1%) to 1,578,900 tons. Since its formation in May 1958 all exports were handled by the Sulphur Export Corporation on behalf of all U.S. Frasch sulphur producers.

The following table indicates the slight change of pattern that occurred :—

	1958	*1957*	*Change*	
	Thousand Tons			*%*
Europe	677	646	+31	+ 5%
Far East	127	117	+10	+ 9%
Australasia	164	144	+20	+14%
Middle East and North Africa	114	135	−21	−16%
North and South America (W. Indies)	497	519	−22	− 4%
TOTAL:	1,579	1,561	+18	+ 1%

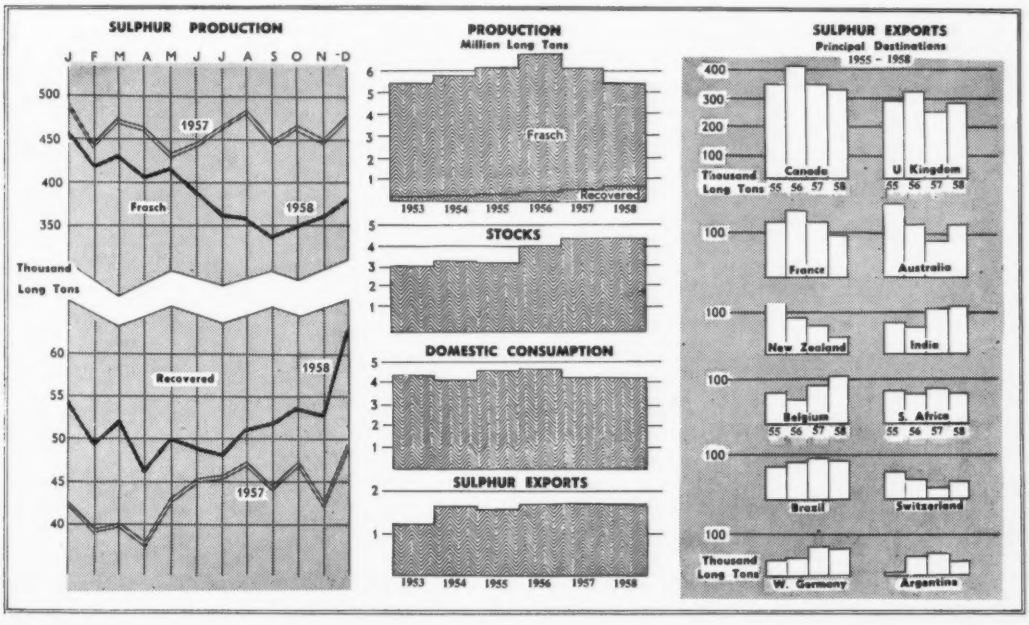


Fig. 7.

The decline of exports to North and South America was mainly attributable to reduced deliveries to Canada (– 15,600 tons or 4½%) to the Argentine (– 7,600 or 16⅔%) and to Brazil and Cuba.

The additional sales to the Far East went entirely to India, where in 1958 over 114,000 tons were sold representing an increase of 11,700 tons (11½%). The reduced sales in New Zealand (– 24,000 tons or 37%) were offset by greater exports to Australia (+44,400 tons or 55½%). Exports to Africa and the Middle East were adversely affected by competition of Mexican Frasch sulphur, which caused a reduction of sales to Tunisia (−12,700 tons), and the Union of South Africa (−14,400 tons), sales to Iran also declining by 9,000 tons. Partially offsetting these reverses were increased sales to Algeria (+7,400 tons) and Israel (7,500 tons).

As in 1957 about two-thirds of total exports, which are directed to all parts of the world, were provided by Freeport Sulphur Company, one-quarter by Texas Gulf Sulphur Company and the balance by Jefferson Lake Sulphur Company.

Consumption

Apparent sales of Frasch sulphur during 1958 totalled 4,625,300 tons. Although this was 379,800 (7½%) less than in 1957, the rate of decrease compared with the previous year had been slowed down appreciably. As indicated above, exports were slightly above the 1957 level and the reduction in sales was therefore wholly attributable to devolopments in the United States domestic market. Although the severe industrial recession made some impact on the sulphur using industries, it is estimated to have accounted for little more than one-third of the total decline in apparent consumption. Of greater account was the expansion by 118,000 tons to 599,300 tons of recovered sulphur delivered to industry and the increase in imports of Frasch sulphur from Mexico, which during 1958 rose by 130,000 tons to 600,000 tons. The main weight of Mexican

Stauffer Chemical Company plant completed early 1958 at Le Moyne, Alabama. In foreground, carbon disulphide plant incorporating 140 tons per day sulphur recovery unit and middle distance, sulphuric acid plant.

imports continued to bear on the Eastern Seaboard markets where traditionally Texas Gulf Sulphur Company has the bulk of its customers and it is this feature which is thought to account for the severe drop in Texas Gulf's domestic business in recent years. Freeport Sulphur Company on the other hand, in the domestic market still enjoy the comparative shelter of the protected Mississippi Valley and Great Lakes markets.

It is estimated that domestic consumption of sulphur in all forms totalled approximately 5.6 million tons, 3% less than in the preceding year. The relatively good results of the fertilizer industry and several key sectors of the chemicals industry nearly compensated for the decline in the activities of the main sulphuric acid users, such as steel, petroleum, pigments and textiles, and of textiles, paper and rubber in the non-acid sector. The rapid expansion of the steel industries' activities in the closing months of the year contributed much to the more balanced picture. The consumption pattern of sulphurous raw materials remained practically unchanged with the consumption of brimstone amounting to about 4.3 million tons of domestic and Mexican origin, representing about three-quarters of total U.S. usage. Domestic supplies of sulphurous raw materials other than brimstone were augmented by the import of Canadian pyrites concentrates containing approximately 160,000 tons sulphur.

Total production of sulphuric acid in 1958 amounted to 15.84 million short tons, a decline of approximately 2¼% compared with 1957. This decline occurred almost exclusively in chamber acid (−12%) and in fortified spent acid output (−2½%). Installed capacity, which at the beginning of 1958 amounted to 20.45 million tons, further expanded and it is estimated that during the year employment of plant capacity declined to about 75%. The principal plant projects in 1958 were linked with the oil industry. The large sludge acid based plant of the Stauffer Chemical Company at Hammond, Indiana (400 tons per day 100% H_2SO_4) came on stream as did Allied Chemical Corporation's versatile plant, based on sludge acid, H_2S and brimstone situated adjacent to Shell Oil Company's Anacortes oil refinery. Several new sulphuric acid plants were brought on stream to meet growing uranium and titanium oxide requirements.

Outlook

Although the United States sulphur industry anticipated that 1959 would bring significant expansion of activity, following the early signs during the autumn months of the cessation of the industrial recession, results during the early part of the year have not so far borne out these hopes. Only in conjunction with the high level of activity in the steel industry, where production is booming, mainly in anticipation of a strike in mid-1959, has sulphuric acid demand substantially exceeded end-1958 levels. So far acid use for fertilizers, textiles, pigments and oil has failed to come up to expectations. The effect of this on the balance of the United States sulphur industry could be serious. Although the United States sulphur exports are likely to be maintained at 1958 levels expansion of recovered sulphur supplies, coupled with increased pressure of Mexican exports, would tend to narrow domestic outlets for Frasch sulphur at a time when production capacity is once more expected to increase. Early in 1959 the Freeport Sulphur Company plans to bring on stream Lake Pelto dome which promises to become, if not a major, at least a substantial supplier of Frasch sulphur with an expected long lease of life. Simultaneously, according to recent reports, construction work on Freeport Sulphur Company's giant off-shore installation at Grand Isle dome is progressing rapidly and early 1960 this also may be expected to come on stream. By the end of 1958 stocks of Frasch and recovered sulphur had risen to practically one year's consumption, the highest level since the end of World War II, but still substantially below the level of stocks in the mid-thirties when 18 to 24 months supply was not unusual. Similarly in those days the employment of capacity was often less than would be considered alarming today. The readjustment from a 20 year boom period to these conditions may be painful to Frasch sulphur company managements and stockholders alike, but it would seem that in the long term interests of the sulphur industry preservation of this important reserve and support to a healthy price structure throughout the entire sulphur industry may have to be accepted.

SULPHUR IN MEXICO

DURING 1958 Mexico's sulphur industry consolidated its position in world sulphur markets and at the same time re-affirmed the important rôle which it now plays in the country's economy. Despite the impact of last year's world-wide stagnation and even recession of economic activities and the weakness in world commodity markets, which greatly influence her foreign revenue, Mexico's economy continued to expand although at a lower rate than in previous years. In real terms the Gross National Product rose 4% and production rose in most industrial sectors. Mining was one of the few exceptions and activity declined 2.7%. In the non-ferrous metal mining and refining industries which are still Mexico's second largest foreign exchange earners, production dropped 5.3% primarily as a result of reduced world prices and the imposition of quota restrictions on lead and zinc in the United States. Precious metal production declined slightly (0.4%) but mining of non-metallic ores rose 15½%, mainly under the impact of sulphur, now established as Mexico's sixth largest export industry. In excess of one million tons for the first time in the history of the industry, production of sulphur in all forms totalled 1.27 million tons, 18¾% more than in 1957. Continuing its expansion, the domestic market in 1958 absorbed 91,000 tons brimstone but the industry's prosperity remains linked with the ability of the U.S. principals of the all-Mexican subsidiaries who exploit the dome deposit on the Isthmus of Tehuantepec by the Frasch process, to maintain and expand markets for Mexican sulphur throughout the world and notably in the United States. In 1958 exports totalled 1.07 million tons, an increase of 22% over those of 1957. The following table indicates the supply balance of Mexico's sulphur industry :—

	Frasch	*Recovered*	*Native rock*	*Total*
	Thousand Tons			
Production ...	1,202	51	19	1,272
Deliveries				
Exports	1,066	—	—	1,066
Domestic ...	13	60	18	91
Addition to Stocks	123	No data	No data	123
Stocks on 31/12/58	828	No data	No data	828

A notable feature in Mexico's chemical industry has been the further growth of her sulphur-using industries and the ready availability of this basic raw material is acting as a strong stimulus. The sulphuric acid sector remained very active in 1958 and output rose about 10% to 270,000 tons (100% H_2SO_4); output of fertilizers and sulphuric acid dependent chemicals expanded correspondingly.

Production

Of Mexico's sulphur output of 1,272,064 tons, 94½% was contributed by three Frasch

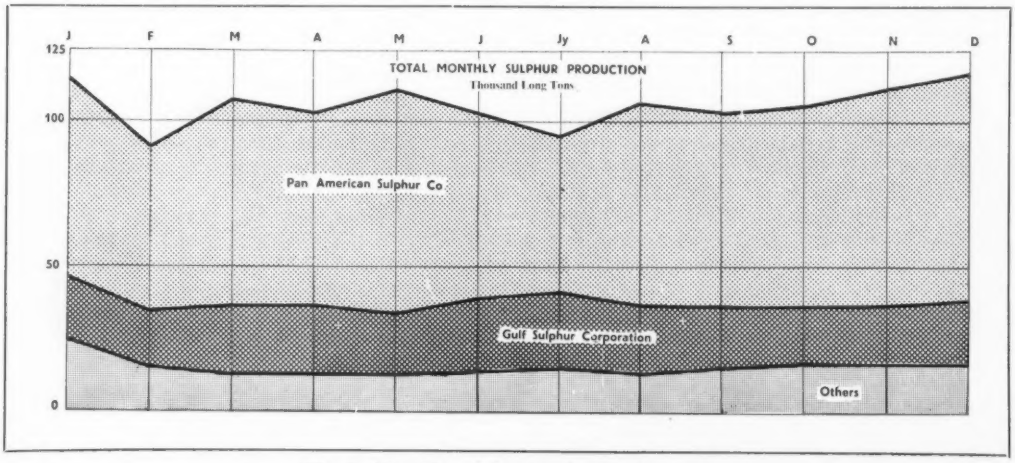


Fig. 8. Monthly sulphur production in 1958.

producers, the subsidiaries of Pan American, Gulf Sulphur and Texas Gulf Sulphur Companies, 1½% was derived from native sulphur rock and the balance of 4% was recovered from natural gas cleaning by Petroleos Mexicanos. Although total output in 1958 rose by 200,000 tons to reach a level of 2½ times that of three years ago, the competitive state of world markets allowed little more than about 60% of installed Frasch sulphur capacity to be utilised. Installed sulphur recovery capacity was also, but to a lesser extent, in excess of production, but here the limiting factor may be found in the tenor of the petroleum industry's activities.

Details of sulphur production are as follows :—

	1958	*1957*
Frasch Sulphur		
Azufrera Pan Americana ...	821,990	723,000
Azufre de Veracruz	265,452	180,000
Exploradora del Istmo ...	115,000	120,000
Refined from Native Rock		
Negociacion Minera	18,880	18,000
Recovered Sulphur		
Petroleos Mexicanos	50,842	37,000

PAN AMERICAN SULPHUR COMPANY

Production at the Jaltipan dome during 1958, totalling 821,990 tons was about 99,000 tons (14%) greater than in 1957. This output originated from some 20 wells which are reported to have continued yielding at an economic hot water : sulphur ratio, believed to be about 1,400 gallons per ton of sulphur. Installed boiler capacity and water storage facilities of 5 million gallons per day indicate that last year's operations employed little more than 55% of the rated plant capacity. Almost the entire crude sulphur output was passed through the filtering plant and the installation in the autumn of a sulphuric acid washing unit enabled the company to produce a substantial part of the output in especially pure condition and bright yellow colour. During the year the carbon content of the crude sulphur was reported to have declined and its colour improved, due it is opined, to satisfactory temperature conditions over a sufficiently large area of the rather shallow dome which do not favour the formation of carbon/sulphur compounds.

Shipments in 1958 totalled 808,000 tons of which all but 11,927 tons delivered to domestic consumers, were exported. Compared with 1957 these results represent an increase of 130,000 tons (19%). Year end stocks totalled 552,000 tons representing a modest increase of 14,000 tons during the year.

GULF SULPHUR CORPORATION

At the Las Salinas dome the company's Mexican operating subsidiary Cia de Azufre Veracruz S.A., produced during 1958 a total of 265,452 tons, representing an increase of 85,000 tons (47%) over the preceding year's level of operations. Production difficulties mainly connected with unsatisfactory working of bleed wells and excessive pressures in the compact and deep Las Salinas dome hampered the company's efforts during the early part of the year and output rarely exceeded 700 tons per day. Most of the technical troubles were resolved during the early autumn, but although average daily production during the second half year rose to 800 tons the company was unable to narrow the gap between production and shipments and so arrest the drain on stocks. Shipments of 270,000 tons, of which all but 1,000 tons went to overseas customers, exceeded the year's production by 5,000 tons and year-end stocks are estimated to have receded to 60,000 tons. On December 1st the company's President, Mr. Stuart F. Dorman, resigned and Mr. William Bellano was appointed in his place. Mr. Tom J. Brown was appointed Vice-president with the special responsibility of Sales.

TEXAS GULF SULPHUR COMPANY

Operations by Cia. Exploradora del Istmo resulted in 115,000 tons brimstone being produced. None of the output of the Nopalapa dome, which had started operating on 7th February 1957 has yet been marketed and it is stored in a vat at the mine site now holding about 230,000 tons.

TEXAS INTERNATIONAL SULPHUR CO.

Although originally due to start operations in spring 1958, delays in completing the company's Frasch sulphur plant and field installations prevented the company from advancing development work and at the end of the year no date had been fixed for steaming to start. When completed the plant is scheduled to operate at a daily rate of 500 tons sulphur.

Other Sources of Supply

Sulphur Rock: Operations by Negociacion Minera and other native sulphur ore producers, notably in lower California produced 18,880 long tons of sulphur during 1958. Deliveries totalling 18,000 tons were wholly destined to domestic consumers.

Recovered Sulphur: Production during 1958 of 51,000 tons originated exclusively from the natural gas treatment plant at Poza Rica, as sulphur recovery at some of Petroleos Mexicanos (Pemex) oil refineries had not yet started. The entire output augmented by withdrawals from stockpile was delivered to domestic markets.

Domestic Consumption

The bulk of domestic consumption in 1958 of 91,208 tons brimstone was consumed in the manufacture of sulphuric acid. There are at present ten brimstone acid plants with a rated daily production of 760 tons, and this was augmented at the close of the year by the completion of the sulphuric acid plant of Guanos y Fertilizantes at Cuautitlan which has a daily capacity of 150 tons. The rapid expansion of domestic acid facilities for the fertilizer, titanium and chemicals' industry points to the addition during 1959 of 500 to 800 tons per day additional acid capacity. Part of the sulphur needs of Mexico's acid industry are met from the exit gases of two non-ferrous metal smelters which have an installed capacity of 100 tons per day (100% H_2SO_4).

Exports

As in the preceding year only two producers, Pan American and Gulf Sulphur Corporation, were shipping abroad, as Texas Gulf Sulphur Company continued to stockpile the company's restricted output. The value of Mexican sulphur exports in 1958 rose $1.2 million to $23.2 million, the sixth largest foreign exchange revenue in Mexico's foreign trading. Despite this increase the average value per ton declined from $25\frac{1}{2}$ per ton to $21\frac{3}{4}$.

Exports of Mexican sulphur totalled 1,066,300 long tons in 1958, showing an increase of 186,800 long tons (21%) over 1957.

Once again exports to the United States expanded, and in 1958 they were 607,600 tons, representing an increase of 135,000 tons (29%) over 1957. Exports to France, despite the availability of domestic recovered sulphur from Lacq, increased from 69,600 tons to 115,700 tons. This expanded interest in Mexican sulphur was due to the existence of bilateral trading facilities which enabled France to buy sulphur from Mexico without imposing a drain on her foreign exchange reserves. Due to the growth of fertilizer and chemical activities, exports to South Africa increased by 25,600 tons, whilst mainly as a result of greater shipments of Gulf Sulphur Corporation's material, sales to Australia expanded by 16,600 tons to meet the increased demand for sulphuric acid which for the first time exceeded the one million ton mark. Exports to the United Kingdom were reduced by 22,200 tons partly due to the decline in rayon activities, in particular by Courtaulds whose sulphur requirements for carbon disulphide manufacture were 10,000 tons less, and also owing to liquidation of Government stocks reducing the level of total imports.

An analysis of exports of Mexican sulphur by destination is shewn in the following table:—

	1956	*%*	*1957*	*%*	*1958*	*%*
U.S.A. & Canada	233.4	48.4	472.5	53.9	608.6	57.0
Europe	153.0	31.7	232.7	26.6	240.0	22.5
Australasia ...	40.6	8.4	95.6	10.9	89.6	8.4
Remainder ...	54.4	11.5	75.7	8.6	128.1	12.1
Total 000 Tons	481.4		876.5		1,066.3	

During the past three years exports to the United States and Canada have risen by 375,000 tons and at the same time the importance of this outlet has also been enhanced so that in 1958 nearly three tons out of every five were destined to North American customers.

The constant efforts of Mexican producers to secure new markets is clearly indicated by the rising volume and share of sulphur shipped to countries other than those in Europe and Australasia. The European market which has, over the past three years, grown in quantity has nevertheless become less important in Mexico's export pattern.

Outlook

As in 1958 the Mexican sulphur industry in 1959 will be predominantly influenced by the activities of the Pan American Sulphur Company. Mr. Harry C. Webb in his year-end review forecast that 1959 would see shipments by the Pan American Sulphur Company at about the same level or perhaps slightly in excess of those in 1958. Equally it may be expected that the policy of adjusting the level of production to the rate of shipments would be maintained. Results during the first two months of 1959 bear this out and production of 66,862 tons and 67,184 tons in February are almost identical with those of a year ago. Gulf Sulphur Corporation confidently expect to attain an average daily production of 900 to 1,000 tons after April and the sharp increase during February when average daily production rose to 872 tons, is indicative of this trend. Whereas no change in the Frasch sulphur operations of Compania Exploradora del Istmo may be expected and surface sulphur mining activities are also unlikely to change, the sulphur recovery activities of Petroleos Mexicanos are rising as new plant capacity is being taken into operation. On the basis of these indications it may be expected that during 1959 Mexican production will again total about 1.3 million tons and there is also every indication that the industry's deliveries will exceed 1.1 million tons. To the Frasch industry the expansion of the home market although small will be a welcome outlet and already Pan American Sulphur Company has increased average monthly domestic sales from 1,000 tons to 3,000 tons; similarly Compania Azufrera Veracruz S.A. also increased her domestic outlets, which are to be found mainly in the sulphuric acid and fertilizer industries whose requirements the recovered sulphur

Gulf Sulphur Corporation. The new insulated barge, recently placed in operation has a capacity of 700 tons liquid brimstone.

industry can now no longer fully meet. The sulphur requirements of the mixing and grinding plants in Northern Mexico will continue to be met adequately by the native rock producers.

The key to the Mexican sulphur industry's prosperity in 1959 will be her ability to maintain and improve her sales outlets in the U.S.A. An indication of the industry's efforts in the United States is the establishment (see page 48) by Pan American Sulphur Company of important dry and liquid sulphur storage facilities at Tampa. Nevertheless Mexico's European, African and Eastern markets are of such importance that they warrant special endeavours.

Sulphur in France

Second Stage at Lacq in Operation

THE COMPLETION of the second gas cleaning and sulphur recovery plant at Lacq for Société Nationale des Pétroles d'Aquitaine has raised the capacity to produce brimstone, at the end of 1958, to 350,000 tons* annually. Production during 1958 totalled 128,527 tons of which 71,607 tons were delivered to the home market and 48,186 tons were exported. Throughout the year the company has been fully utilizing available gas cleaning facilities and the clean gas, as well as by-products in particular elemental sulphur, found ready markets. Construction of the gas pipeline has progressed according to schedule and Nantes has been consuming gas from Lacq for several months. The pipeline to Lyons is on the point of completion while that to Paris will be ready next year. In order to meet peak consumer requirements from their present capacity Société Nationale des Pétroles d'Aquitaine are pumping surplus gas during low consumption periods to natural underground storage reservoirs at Lussagnet. Located 50 miles north of Lacq this reservoir is capable of holding some 1,000 million cubic metres of cleaned gas.

Sales

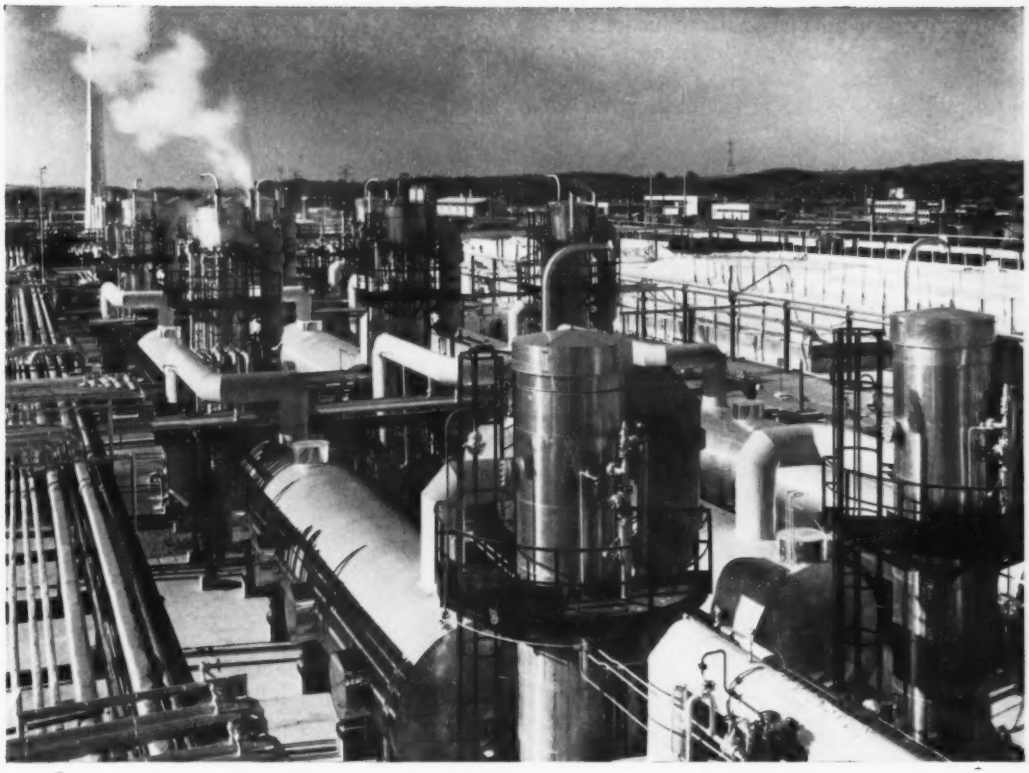
Shipments of sulphur are effected through the port of Bayonne. The completion of new loading facilities is scheduled for the end of June when it will be possible to load up to 1,000 tons sulphur per hour. The sulphur is transported to the stockpile at Bayonne in specially designed railway wagons in complete train loads which are automatically unloaded. Movement from the stockpile to the company's pier is effected by a conveyor belt which incorporates automatic weighing facilities. At present the pier provides berthing facilities for two or three medium-sized ships.

As expected the French market has taken the greater part of the sulphur output and domestic sales of 71,607 tons were directed to non-acid as well as acid sulphur consumers. Of the 48,186 tons exported, W. Germany took 19,124 tons and Great Britain 15,278 tons. Purchasers of smaller tonnages were Sweden 2,743 tons, Israel 2,312 tons, Belgium 5,665 tons, Austria 3,050 tons and Switzerland 23 tons. Most of the sales were, in fact, small parcels and have been in the nature of trial shipments to determine the suitability of this new supply in established plant operations. In view of its high purity Lacq sulphur appears to have found universal acceptance, especially amongst non-acid users. The company is at present establishing a wide network of sales agents.

Summary

Construction work on the third phase of the Lacq project is now well advanced and it is foreseen that the additional sulphur recovery capacity of 350,000 tons per year will be brought into operation between May and July of this year. Then, the gas cleaning installations will be capable of treating 10 million cubic metres of gas daily and installed capacity of the sulphur recovery facilities will have reached 700,000 tons per annum. Due to the phasing

* All quantities in tonnes of 1,000 Kgs.



Lacq. Sulphur recovery convertor units forming part of the completed second stage.

of the operations it is expected that production in 1959 will be about 450,000 tons. The sales programme has been centred on the French home market which, it is estimated, will take up to 200,000 tons, whilst the remainder will be available for export. During the current year no difficulties in placing this export surplus are anticipated and the sales to date appear to conform with the company's programme of expanding activity.

ELEMENTAL SULPHUR IN JAPAN

DURING 1958 production of elemental sulphur in Japan totalled about 180,000 tons, the lowest tonnage since 1952 and 30% less than was produced in 1957. This output was contributed by the following producers :—

Matsuo Mining Co.	49,000 tons
Hokkaido Sulphur Co.	29,000 tons
Teikoku Sulphur Industry Co. ...	18,000 tons
Akan Sulphur Mining Co.	17,000 tons
Others	67,000 tons

Throughout the year production appears to have remained at a uniformly low level, mainly occasioned by the restricted rate of activities in Japan's rayon and pulp industries. The recession in Japan's sulphur using industries had started to affect elemental sulphur production in the summer of 1957, soon after this had reached an all-time peak of about 25,000 tons per month. The decline to the current level of 15,000 tons was accompanied by

the cessation of all marginal productions and the closure of several of the smaller mines. With the declining demand mines' stocks of elemental sulphur have been increasing and at the end of 1958 they are reported to have totalled 13,600 tons, representing an increase of about 20% over the tonnage held at the end of 1957. Consumers stocks on the other hand declined and the reported decrease of 60% during the year to leave only a total of some 10,000 tons in the hands of consumers.

Recovered Sulphur

Recovery of brimstone from oil refinery gases has been confined in 1958 to one oil refinery, where plant with a monthly recovery capacity of 200 tons brimstone has been in operation. As far as is known no additional sulphur recovery plant has been installed although several oil refineries have given close attention to this aspect of their refinery operations. It has been estimated that as much as 90,000 tons sulphur annually might be recovered if plant were installed at all the refineries, many of which are located near the principal consumers of elemental sulphur. It is this aspect of proximity which has occasioned much anxiety amongst the established elemental sulphur producers as to the future impact of this potential source of supply.

Consumption

Although during 1958 the activities of the rayon and pulp industries, the two key consumers of elemental sulphur in Japan, remained low the serious decline from the peak levels of mid-1957 appears to have been arrested. Severe control by the Japanese Rayon Producers' Association, operating in conjunction with appropriate Government Departments, influenced the level of production and exports and it is estimated that output of rayon filament and staple fibre in 1958 was approximately 25% below that of 1957. Even so, with an output of 527.8 million lbs., Japan remains the world's largest staple fibre producer. The distribution by main consumer groups of elemental sulphur consumption was as follows :—

Consumed for:	*Long Tons*			*%*
	1958	*1957*	*1956*	*Change 1957-58*
Carbon disulphide	90,000	129,000	129,000	− 30
Pulp	75,000	89,000	93,000	− 15
Synthetic fibre ...	13,000	13,000	11,000	Nil
Others	11,000	18,000	22,000	− 39
Total	189,000	249,000	255,000	− 24

The principal reduction occurred in the use of sulphur for carbon disulphide manufacture but the decline of 30% is occasioned partly by the impact of sulphur recovery, which was started in a number of CS_2 plants in April 1957.

Exports

During 1958 exports of elemental sulphur totalled 3,800 tons, destined to various Far Eastern countries under contracts concluded in 1957. The high cost of production of elemental sulphur in Japan, occasioned by the adverse nature of ore bodies and costly mining and refining methods, continues to accentuate Japan's handicap in to-day's highly competitive world markets.

Prices

Due to the continued decline in elemental sulphur demand prices were considerably reduced during the year. In February the price of sulphur dropped by 880 yen per ton and continued to fall steadily throughout the year. By November domestic consumers were able to buy their supplies at prices between 19,000 to 20,000 yen* per ton. The carbon disulphide market also weakened and by the end of the year the price had fallen to 46,500 yen per metric ton, a reduction of 1,500 yen (3%) compared with the same period of 1957.

Outlook

The Government's ban on sulphur imports remains together with that on the issue of licences for the sale of foreign sulphur in Japan unless demand greatly exceeds supply which, with an estimated national annual capacity of 300,000 tons, is unlikely to occur. Moreover it is probable that rayon and staple fibre producers, whose export prices had been severely affected previously by the high cost of domestic sulphur, will seek further price concessions from sulphur producers, particularly in view of low world prices.

* £1 = 1,009 Yen.

SULPHUR IN THE UNITED KINGDOM

CONSUMPTION of sulphur in all forms in 1958 amounted to 1,078,000 tons, a reduction of 67,000 tons (5¾%) compared with 1957. This change does not accurately reflect the narrow movement of the index of industrial production in the United Kingdom (1954 = 100), which during the past four years has fluctuated as follows: 1955 105, 1956 107, 1957 107, 1958 106. The decline in demand has been occasioned by major reverses encountered in some specialized consuming sectors, notably textiles and to a lesser extent in steel and fertilizers. In the case of a considerable number of small users their lower sulphur and/or sulphuric acid needs were in keeping with the reduced or stagnating tenor of industrial activity evident in most sectors up to mid-autumn 1958. The up-turn of business and general production throughout Britain in the fourth quarter also improved the sulphur industry's activities, but the overall favourable picture conceals a wide variation of results in different industrial sectors.

Indigenous production of sulphur in all forms totalled 577,000 tons, ½% more than in 1957, although there were greater changes in individual sources of supply. Anhydrite output for acid and ammonium sulphate manufacture continued at a high level. The narrower gap between supply and demand was met by Britain's traditional overseas suppliers of pyrites and brimstone, the latter augmented by the new French supplies. Continued low sea freights and the modest cost of sulphur in world markets enabled the British economy to obtain about 460,000 tons sulphur for an outlay of only £5 million, the most favourable position since 1949 but in keeping with the overall weakness of the commodity markets and favourable terms of trade.

Production and Imports

Anhydrite. Output in 1958 at the three principal mines, Billingham (Imperial Chemical Industries), Long Meg (British Plaster Board Limited, for delivery to the United Sulphuric Acid Corporation) and Whitehaven (Solway Chemicals Limited), is estimated to have totalled 1.7 million tons, representing a modest increase, but again a record total.

Recovered Sulphur. The capacity to recover brimstone in the United Kingdom has been significantly expanded in 1958 following the commissioning of new plant at the Isle of Grain refinery of British Petroleum Limited and a second unit at the Fawley refinery of Esso Petroleum Limited. Sulphur recovery capacity at the end of the year totalled some 80,000 tons annually, but production amounted to 49,561 tons. Whereas in the early years of this development of the sulphur industry recovered sulphur was primarily sold to the regular sulphur users, it is now finding an increasing outlet to sulphuric acid manufacturers, especially as a result of the satisfactory and economic development of its transportation in liquid form. Messrs. F. W. Berk & Co. Ltd. have been prominent in developing this method of sulphur distribution and at present handle practically the entire recovered sulphur of the United Kingdom.

Domestic production in the past two years has been as follows:—

	1958	*1957*
	Thousand tons sulphur content	
Anhydrite	352	351
Spent Oxide*	116	129
H_2S	12	7
Zinc Smelter gases	46	48
Recovered Sulphur	50	39
Pyrites	1	1
	577	575

*Consumed for acid manufacture

Brimstone Imports. Totalling 328,439 tons, United Kingdom imports of brimstone were 2,727 tons (2½%) higher than in 1957. The value was £3¾ million, representing an average of £11 7s. 6d. per ton; the substantial decrease of £3 7s. 6d. per ton was in part due to the world reduction in sulphur prices compared with the previous year and accentuated by the heavy drop in the average cost of ocean freights.

Imports of U.S. Frasch sulphur in 1958 rallied slightly and 255,000 tons were brought into this country, representing approximately 78% of the total brimstone imports, an

increase of over 5%. Imports of Mexican sulphur decreased by 18,600 tons compared with 1957, and amounted to 61,724 tons at an average price of £11 per ton. France for the first time became an important source of sulphur and in 1958 imports from Lacq amounted to 12,624 tons, valued at approximately £11 5s. 0d. per ton.

Pyrites Imports. A heavy reduction of 111,700 tons (31¼%) made the 1958 import total only 245,123 tons, the lowest since 1952. The low average import value (£5 8s. per ton) caused a remarkable decrease in the total cost, which at £1.3 million was £1.2 million less than in 1957.

Cyprus pyrites again accounted for over one-half of the United Kingdom imports (55%) whilst Spanish pyrites lost ground and represented only 20%. Imports of Canadian pyrites fell to 30,000 tons, a reduction of over one-half. Besides these principal suppliers, Sweden (16,000 tons) and Portugal (10,000 tons) increased their share of the market and with an import of nearly 1,000 tons flotation concentrates from St. Patrick's Copper Mines, Eire, for the first time helped to meet the United Kingdom sulphur needs.

Stocks

Acid sulphur stocks totalled 98,500 tons at the end of 1958, a reduction of 4,000 tons (3%). Pyrites stocks fell by 59,500 tons (24%) to 186,200 tons in 1958 as the result of heavily reduced pyrites imports and to accord more with the reduced level of consumption. A further reduction of 14,500 tons (12%) of stocks of spent oxide brought the end-of-year level to 97,500 tons.

Consumption

The total volume of sulphurous raw materials directed to the sulphuric acid industry declined 4% compared with the previous year while that consumed by the non-acid sector has fallen to the lowest level since before the war. The use pattern of different raw materials, which emerged about three years ago, has continued with little change but the decline of total sulphur use has temporarily arrested the strong trend to swing towards greater brimstone use which otherwise would have become apparent. As anticipated, anhydrite use remained strong whereas consumption of elemental sulphur, H_2S and filter cake declining 4%, was less affected than other materials, notably pyrites, the use of which receded 10¾%.

Brimstone. The total demand was reasonably well maintained because of the commissioning of three major brimstone burning plants for Messrs. Fisons Limited at Immingham, British Titan Products Company Limited at Grimsby and Laporte Titanium Limited at Stallingborough.

Imports, mainly from the United States, remained the mainstay of brimstone supply and the contribution made by domestic recovered sulphur production was modest at only about 50,000 tons.

Anhydrite. Consumption of anhydrite for sulphuric acid manufacture rose to a record level in 1958 and totalled 749,000 tons, nearly 2% more than the previous year which was also a record. It represents about 43% of the United Kingdom's total anhydrite use, estimated at 1.7 million tons, the remainder being consumed in direct manufacture of ammonium sulphate by the CO_2 process at the works of Imperial Chemical Industries Limited.

Spent Oxide. Containing the equivalent of about 116,000 tons sulphur, spent oxide usage declined to its lowest level since 1953. The poor showing of this section of the industry is due less to the impact of brimstone use than to the use pattern in specific localities notably the reduction in the manufacture of ammonium

	1958	*1957*	*% Change*	*1958 4th Qtr.*	*1957 4th Qtr.*	*% Change*
Elemental sulphur						
Imported	277,600	289,100	− 4 %	76,300	72,100	+ 6 %
Recovered H_2S and Filter Cake	44,800	43,600	+ 2¾%	13,600	12,200	+12 %
Total Acid Sulphur	322,400	332,700	− 3 %	89,900	84,200	+ 6¾%
Regular Sulphur	91,000	109,000	−16½%	22,700	26,300	−15¾%
Total Elemental Sulphur	413,400	441,700	− 6½%	112,600	112,200	− ⅜%
Pyrites	327,700	366,900	−10¾%	75,500	92,500	−18¼%
Spent Oxide	242,700	263,600	− 8 %	60,800	67,600	−10 %
Anhydrite	749,000	737,100	+ 1¾%	200,600	188,500	+ 6½%
Zinc Concentrates	152,200	158,900	− 4¼%	42,200	42,600	− 1%

sulphate in the North of England. Here, due to lower steel production and reduced gas needs, coke oven activity was cut back and the consequent drop in by-product ammonia resulted in lesser sulphuric acid demand, much of which in these areas is based on spent oxide.

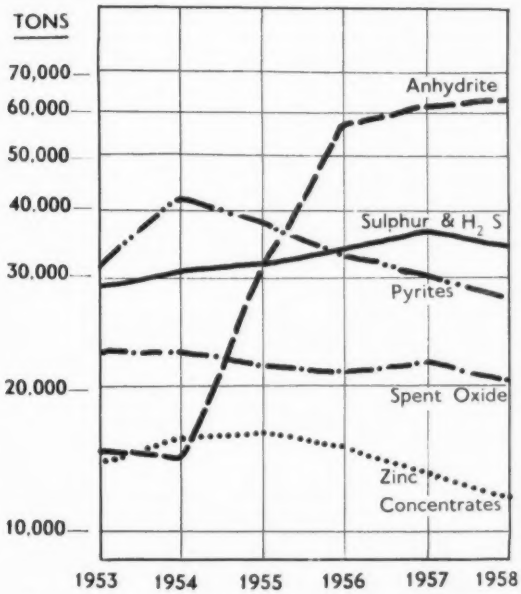


Fig. 9. Average monthly consumption of sulphurous raw materials in the United Kingdom 1953-58.

Zinc Concentrates. Zinc production remained depressed throughout the world in 1958 and the activities of the National Smelting Corporation, whose smelters are at Swansea and Avonmouth, did not escape from the general trend. The sulphur content of zinc concentrates consumed reached the lowest figure for some years at 45,600 tons, and 4% lower than the previous year. The company operate four sulphuric acid plants, two each at Swansea and Avonmouth.

Pyrites. There has been a steady decline in pyrites usage since the peak period of 1954 and this reflects principally the adverse economics compared with brimstone acid in the case of many older plants. During 1958 two small pyrites plants are reported to have closed, mainly on account of old age and an abundance of local acid supplies. Actual consumption of pyrites during 1958 totalled 328,000 tons, a decline of over 10% compared with the previous year and 167,000 tons compared with 1954. As the bulk of active pyrites acid capacity is represented by flash roasting installations, most of the United Kingdom pyrites needs are met by flotation concentrates.

Sulphuric Acid Production*

Sulphuric acid production during 1958 totalled 2,241,100 tons (100% H_2SO_4), a decrease of 94,800 tons (4%) compared with 1957. Acid produced in chambers and towers during 1958 declined by 45,000 tons (8½%) to 482,700 tons, and contact acid declined by 48,700 tons (2⅔%) to 1,758,500 tons; nevertheless its share of total output rose to 78½% whereas chamber and tower acid accounted for 21½% of the total production compared with 22⅔% in 1957. Closure of old plants reduced installed chamber capacity to 621,800 tons of which 78% was employed, a slightly higher ratio of employment than in the preceding year, albeit on lesser capacity. Contact acid capacity rose by 113,530 tons (5½%) to 2,186,850 tons, but reduced acid requirements

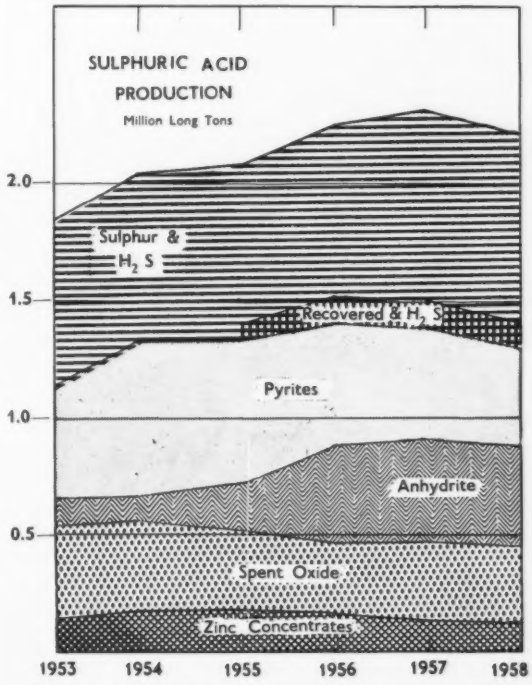


Fig. 10. Sulphuric acid production 1953-58, million long tons 100% H_2SO_4.

* We are indebted to the National Sulphuric Acid Association for placing information at our disposal.

allowed only 80% of plant being employed (87% in 1957).

The start of operations of three new sulphur burning acid plants with a combined total daily capacity of 530 tons (100% H_2SO_4) for Messrs. Fisons Limited at Immingham (175 tons), British Titan Products Company Limited at Grimsby (180 tons), and Laporte Titanium Limited at Stallingborough (175 tons), dominated developments during 1958. The plant for Fisons Limited at Immingham brings the company's total capacity at this location to 420 tons per day and is captively consumed in the manufacture of triple and single superphosphates. The completion of the No. 4 acid plant at Grimsby for British Titan Products Company Limited by Chemical Construction (G.B.) Limited raised daily capacity to 620 tons while the completion in March 1959 of the fifth unit brings the total to 800 tons per day. The company's sulphuric acid production facilities are notable for their compact size, the variety of units to deal with sulphurous raw materials — brimstone burners, flash roasters and fluidised bed roaster — and the means to supply SO_2 gas from one or more roasters or burners to various contact convertors.

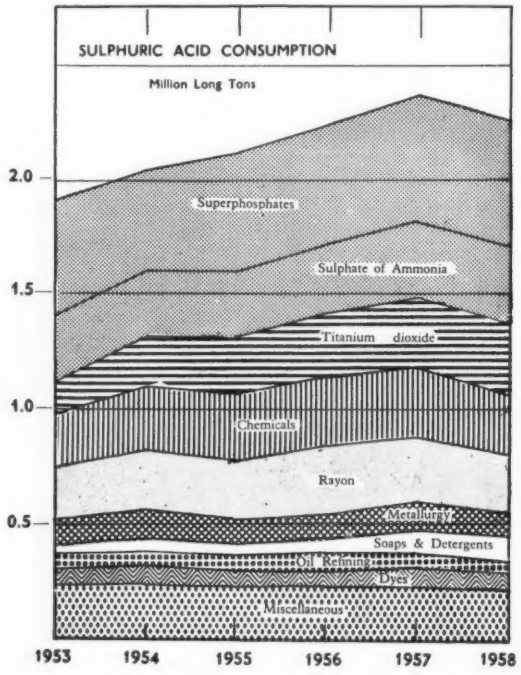


Fig. 11. Sulphuric acid consumption 1953-58, million long tons 100% H_2SO_4.

Two acid plants based on the purification of coke oven gases are due to start operations in 1959. The plant of Appleby Frodingham Steel Company at Scunthorpe is based on a fluidised bed principle* and is being built by W. J. Frazer & Company of Harold Wood. That of Stewarts & Lloyds is the second installation of its kind to be installed at Corby and will convert H_2S from a Collin plant.

Sulphuric acid consumption in 1958 totalled 2,268,000 tons (100% H_2SO_4), a decrease — the first since 1952 — of 103,000 tons (4⅓%) compared with 1957. The decline was the direct result of the recession of industrial activity in the U.K. and might have been greater had it not been for a strong recovery in the last quarter of 1958 when acid use totalled 598,800 tons. Consumption in the various consumer groups was as follows :—

	1958	*%*	*1957*	*%*
	Thousand Tons			
Fertilisers	832.4	36.7	860.9	36.3
Superphosphates	538.1	23.7	543.6	22.9
Ammonium Sulphate	294.3	13.0	317.3	13.4
Titanium Dioxide	322.1	14.2	314.3	13.3
Chemicals	249.6	11.0	302.4	12.8
Rayon and Transparent Paper	240.2	10.6	278.6	11.8
Metallurgy	117.5	5.2	130.7	5.7
Soap, Glycerine and Detergents	117.9	5.2	98.6	4.1
Oil Refineries	55.5	2.5	60.7	2.6
Dyes	75.5	3.3	86.9	3.7
Plastics	40.9	1.8	35.1	1.5
Miscellaneous	216.6	9.6	202.9	8.5
Total	2268.2	100.0	2371.1	100.0

Major changes in acid consumption compared with the previous year were as follows :—

	Change	
	Tons	*%*
Soap, Glycerine and Detergents	19,300	+ 5.1
Titanium Dioxide	7,800	+ 2.5
Dyes	11,400	− 13.1
Metallurgy	13,200	− 10.1
Ammonium Sulphate	23,000	− 7.3
Rayon and Transparent Paper	38,400	− 13.8
Chemicals	52,800	− 17.5

Other important changes, although quantitatively smaller, have been recorded by plastics (+16½%) and oil refineries (8¼%).

Regular Sulphur

This sector of the United Kingdom sulphur industry severely declined during the year and total use of 91,000 tons is 16½% less than in 1957. The main cause for the set-back

* Further details see " Sulphur " number 21, page 38.

was the lower demand for the manufacture of carbon disulphide, reflecting the serious difficulties met by viscose rayon—staple as well as filament—sector, partly due to world-wide competition, partly as the result of the growing impact of fully synthetic man-made fibres. Consumption of sulphur for CS_2 manufacture amounted to only 45,000 tons, and 13,000 tons less than the previous year. A decline of about 7% is reported in the needs of the sulphur dioxide and sulphite producers. The rubber industry is feeling the effects of the rapidly growing plastics industry and sulphur consumption for rubber compounding is estimated to have totalled 9,000 tons. The bulk of this is consumed by the tyre manufacturers who use it in almost equal proportions for tyres and "other" rubber products. Ebonite production, which requires relatively large quantities of sulphur, has been declining in recent years, as better acid-resisting plastic materials are produced; provisional data indicate a decline of nearly one thousand tons of sulphur in this sector alone. Demand by other sulphur consuming industries is reported to be slightly lower than in previous years.

Outlook

The efforts of the United Kingdom Government to accelerate the tempo of the economy and to stimulate industrial activity is expected to cause an increase in 1959 sulphur use in sulphuric acid manufacture. During the last weeks of 1958 this positive trend was already evident in a number of sectors, notably titanium dioxide and plastics and to some extent also in the rayon industry, but the factor determining whether 1959 sulphur consumption will be average or high is expected to be the level of activity in fertilizer manufacture. Several new sulphuric acid projects are coming on stream during the year, notably brimstone acid plants of Cowburn & Cowpar of Trafford Park, Manchester, and British Titan Products Company Limited at Grimsby and Billingham. An aspect of the United Kingdom sulphur industry, which is growing in importance and is likely to make itself felt increasingly during the year, is the utilisation of by-product hydrogen sulphide in the coal gas industry. Town gas producers, notably the very large works, now plan to install gas cleaning plant based on wet processes; coke oven operators are looking with keen interest to the imminent start of Appleby Frodingham Steel Company's fluidised bed ferric oxide de-sulphurisation plant and the Benfield process is being applied in conjunction with the total coal gasification plant. All this emphasises the need for a co-ordinating policy to ensure that the most economic use is made of a potentially large volume of H_2S which may become available from these sources. Also this year recovery of sulphur in copperas and pickle liquor is due to start on a commercial scale thereby significantly augmenting indigenous sulphur supplies. The project of great interest in the United Kingdom anhydrite acid sector is the 50% expansion of the Solway Chemical acid plant which is expected to be completed in 1960 to meet the rising acid requirements for wet phosphoric acid and polyphosphates. It is expected that total sulphuric acid output in 1959 will reach 2.4 million tons (100% H_2SO_4) and, as pyrites usage now appears to have steadied at an equivalent of about 140,000 tons yielding 400,000 tons acid annually, the anticipated rise in acid output is expected to be met by greater brimstone use. The existing plant capacity is still adequate to meet this and even higher production demand. The possibility must not be excluded that some of the older plants, especially those based on pyrites, may be closed. The modest increase to about 70,000 tons in brimstone recovered at oil refineries should not materially affect the heavier import programme in which supplies from France may be expected to play a substantial part and are likely to account for 12 to 14% of total shipments into this country. United States Frasch sulphur is assured of 70% of the market in which Mexican producers hope to expand their sales mainly of acid sulphur. The size of the United Kingdom market, which in 1959 is likely to become the largest single brimstone importer in the world, supplanting Canada, makes it an even more attractive outlet to all major sulphur suppliers. Coupled with low ocean freights these competitive supply conditions hold promise that the United Kingdom will continue to enjoy cheap sulphur and consequently cheap sulphuric acid.

Australia

SULPHURIC ACID IN 1958

SULPHUR CONSUMPTION IN ALL FORMS IN 1958 was 15,000 tons (4¼%) greater than in 1957, and at 366,000 tons was the highest on record. Sulphuric acid production also rose to a level not previously attained, and with a total of 1,009,000 tons (100% H_2SO_4) was 34,000 tons (3%) greater than in 1957. Indigenous sources of sulphur supply contributed fractionally less to Australia's requirements and declined to just under 50% of total sulphur use.

Consumption of various raw materials for sulphuric acid manufacture is estimated to have represented 353,800 tons sulphur in all forms, an increase of 11,800 tons (3½%) compared with 1957.

Brimstone consumption expanded 9,000 tons (4%) to nearly 174,000 tons, whereas the use of pyrites declined 4% to 243,000. The Lake George Mining Company once more shipped pyrites concentrates to consumers in New South Wales whilst Mt. Morgan Ltd. is reported to have encountered sales difficulties. Although the volume of "other materials" which are represented mainly by sulphur in lead smelter exit gases remained unchanged, the volume of sulphur so used increased 17% to 27,100 tons sulphur-equivalent.

Consumption of non-acid sulphur in 1958 amounted to 11,900 tons, an increase of 3,200 tons (36½%) over 1957. The increase is mainly due to the coming on stream of a new carbon disulphide plant at Tomago, New South Wales.

Raw Materials Used for Acid Manufacture	*1958*	*1957*
Brimstone	170,205	163,003
Pyrites	243,142	253,085
Zinc Concentrates ...	152,147	138,537
Spent Oxide	12,857	14,379
Other Materials	272,094	272,003
Total Raw Material	**850,445**	**841,007**
Total Acid Sulphur Equivalent	**353,800**	**342,000**
Non-Acid Sulphur	**11,900**	**8,700**

The plant is operated by Hunter River Chemical Company, a wholly owned subsidiary of Australian Cream Tartar Company Pty. Limited, a company in which Stauffer Chemical Co. Inc. of New York have a 34% stock interest.

Sulphuric Acid

Production of sulphuric acid in 1958 of 1,009,034 (100% H_2SO_4) was 34,000 tons (3%) greater than in 1957. Contact acid manufacture amounting to 445,240 tons (100% H_2SO_4) represented 44% of acid output compared with 43½% in 1957. The general trend towards more contact acid was emphasised during the last quarter when 50.5% of total acid output originated from contact plants, the largest proportion to date. Although brimstone acid output expanded by 20,000 tons to 498,000 tons it failed by 74,000 tons to reach the peak level of 1955. By-product acid output from zinc smelters totalled 118,000 tons (100% H_2SO_4), an increase of 11,000 tons (10¼%) over 1957. This was mainly attributable to increased activity at Risdon, and it is expected that this sector of the industry will continue expanding as additional plant in various chemo-metallurgical projects comes on stream.

Production of sulphuric acid for 1958 is as follows :—

H_2SO_4 Production from	*'000 tons 1958*	*%*	*'000 tons 1957*	*%*
Brimstone	498	49.4	478	49.0
Pyrite	303	30.4	309	31.7
Zinc Concentrates ...	118	11.9	107	11.0
Spent Oxide	13	1.5	15	1.5
Other Materials ...	77	7.8	66	6.8
Total Production ...	**1,009**	**100.0**	**975**	**100.0**
% Contact		44.2		43.5

Notable developments in the sulphuric acid industry in 1958 were the commissioning of the 100 tons per day unit at the Geelong Refinery of Shell Oil Co. of Australasia and the third contact sulphuric acid plant at Risdon, Tasmania, for the Electrolytic Zinc Co. of Australasia Limited with a daily capacity of 180 tons. Sulphuric acid production at both plants is earmarked for fertilizer

usage. The output at Geelong is consumed in the adjacent plant at Cresco Fertilizer Limited while that at Risdon is used captively by Electrolytic Zinc and helps to increase the output of both ammonium sulphate and superphosphate. With the completion of the additional acid capacity at Risdon there are facilities to produce annually 170,000 tons (100% H_2SO_4). At present the largest installation in Australasia, it plays an important part in the utilisation of indigenous sulphur resources.

Outlook

The record production which the Australian sulphuric acid industry achieved in 1958 is likely to be surpassed in the current year in spite of the uncertainty over the recommendation of the Tariff Board which will be meeting shortly to discuss future policy. The use of indigenous pyrites has been checked, while the utilization of the sulphur content of oil refinery gases and zinc and lead smelters which is proving more efficient and economic continues to grow. The recovery of elemental sulphur from the Altona refinery of Standard Vacuum Oil Co. will further supplement these domestic sources. Once the decision is reached by the Tariff Board as to the future level of the Sulphur Bounty a spate of new plant projects are likely to be announced to meet the apparent sulphuric acid demand.

SULPHURIC ACID FOR EUROPOORT AREA

Holland takes a New Look at Pyrites

MORE THAN USUAL interest all over Europe among those concerned with the production of sulphuric acid, its raw materials and with its various uses was aroused by the announcement that the old-established Albatros Company of Utrecht plans to erect alongside its existing Pernis works a large modern sulphuric acid plant based on pyrites. For this enterprise, Albatros will form a new subsidiary jointly with Cyprus Mines Corporation whose flotation pyrites will be used probably at an annual rate of about 80,000 tons. The project is of special significance not only in relation to the foreseen rapid industrial development of the Rotterdam area, but also as indicating what may prove to be a turning point in recent trends of pyrites production and consumption in Europe.

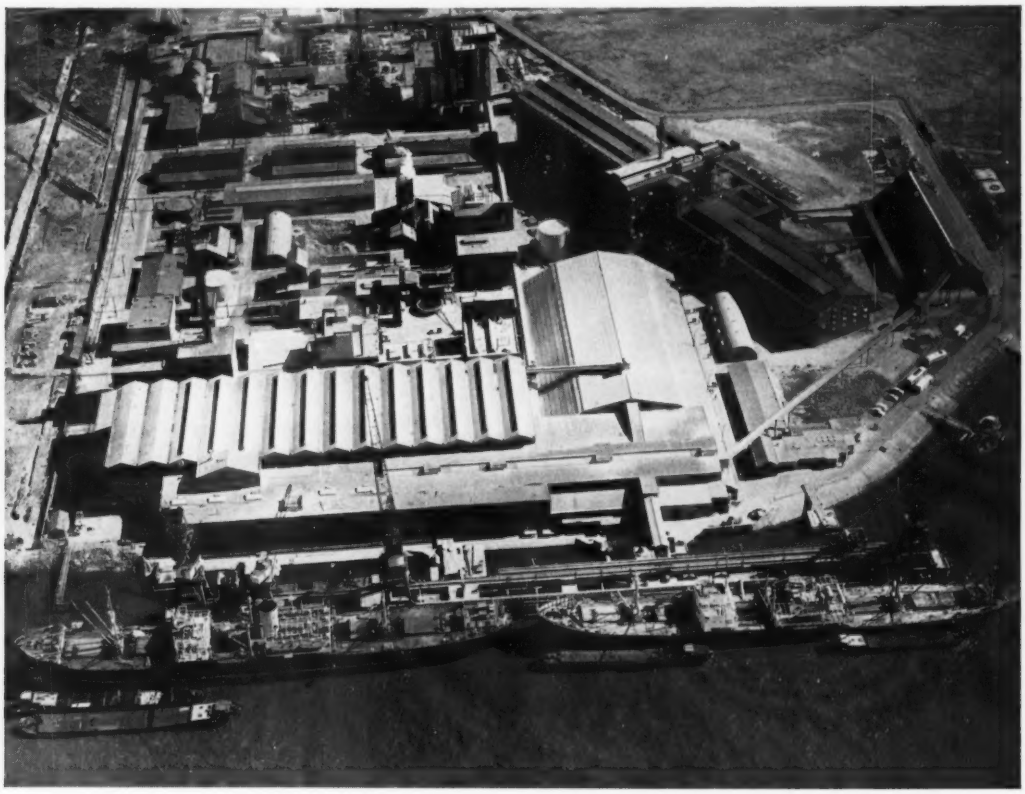
Mining and Metallurgical Agency Ltd., to whom we are indebted for some details of the project, comment as follows : " It is written in the Book of Genesis that, when Lot with his daughters and his backward-looking wife had gone forth from the doomed city of Sodom, ' the Lord rained brimstone ' on the land ; and pyrites producers have had some reason in recent years to suppose that this dramatic page of history was, most inconveniently, repeating itself before their eyes. New discoveries and recoveries of elemental sulphur so greatly increased, anyhow for the short and perhaps for the medium term, the availability at competitive prices of this convenient raw material, that fashion was inclined to turn her always fickle face away from pyrites, perhaps too readily forgetting past crises and almost certainly overlooking future possibilities. What is now emerging may well be a " new look " of lasting significance, and it is certainly launched under excellent auspices."

Albatros Superfosfaatfabrieken N.V. is a merger of Amsterdamsche Superfosfaatfabrik N.V. (Amsterdam and Pernis) and the old United Chemical Works (Kralingse Veer, Groningen, and Zwijndrecht). This group has a record of successful production and expansion extending now over more than three-quarters of a century. Jointly with Fisons Limited it has established a South African subsidiary having a number of factories which together cover almost half the fertilizer trade of that country, as well as a Canadian subsidiary with works at St. John, New Brunswick, and at Quebec. The Canadian factories have not only an increasing local trade but export also to adjoining United States terri-

tories. In Maine these supplies are handled locally by Albatros Fertilizers Inc. The Dutch parent also maintains offices in London and New York. Another subsidiary owned in partnership with Fisons at Salisbury, Rhodesia, produces granular mixed fertilizers. In Eire also, Albatros holds an important interest in a granular mixed fertilizer plant at New Ross.

Cyprus Mines Corporation, although primarily a mining house with operations in North and South America and in Europe, has important interests in timber and oil as well as in other industries. Its flotation pyrites, a by-product of copper recovery in Cyprus, have for many years been used by acid-makers in Northern and Western Continental Europe and, since the war, increasingly in England. For some time past the Corporation has been known to be ready to study any mutually useful form of capital collaboration with its customers, most of whom, like Albatros, are of many years' standing.

The new plant's location on the Rotterdam New Waterway is an almost ideal site in relation to the projected industrial development of the Botlek and Europoort areas. With modern facilities for handling ocean-going ships, it will also benefit from the rail and canal connection with the principal consuming centres of the Common Market. This interesting project should come to the production stage towards the end of 1960.



Aerial view of Albatros Superfosfaatfabriken N.V. fertilizer factory at Pernis. The projected acid plant will be sited here.

ATLAS FERTILIZER CORPORATION

New Major Fertilizer Plant in the Far East

BUILT TO MEET the growing fertilizer needs of the Republic of the Philippines, the new fertilizer plant of the Atlas Fertilizer Corporation at Sangi, near Toledo, on Cebu Island, has now been in full-scale operation for nearly one year. Originally conceived in 1956 as a subsidiary project to the Atlas Consolidated Mining & Development Corporation's main activities of producing copper concentrates, the fertilizer scheme became so large and specialised that the Board of Directors decided to give the project a separate corporate status. Capitalized at a cost of some $P 15 million, the Atlas Fertilizer Corporation was formed on October 10th 1957; construction work, which was supervised by the engineers of St. Gobain, commenced in April 1957 and was completed by May 1958 when the plant entered full production.

General view of the fertilizer plant at Toledo. Left to right, mixing and granulating plant, superphosphate storage, phosphoric acid and superphosphate plant, sulphuric acid plant.

Sulphuric and Phosphoric Acid

The main fertilizer products are single and triple superphosphate and, with the aid of imported materials, granulated mixed fertilizers. The plant's requirements for sulphuric acid and phosphoric acid are met from integrated units. Sulphuric acid is produced in a contact plant with a capacity of 120 tons per day (100% H_2SO_4). The sulphur needs are supplied in the form of iron pyrites concentrates which arise as a by-product in the flotation of copper concentrates. During 1958 production of by-product iron concentrates totalled 17,140 short tons; this year the tonnage is expected to increase as, in addition to meeting the acid plant's needs for a complete year, there are the sales of pyrites to the National Power Corporation which has a capacity to consume some 18,000 tons annually.

The sulphuric output is consumed by Atlas Fertilizer Corporation either for the manufacture of phosphoric acid or the acidulation of phosphate rock for single superphosphate. The phosphoric acid plant has a daily capacity of 25 tons 100% P_2O_5 and employs the St. Gobain process.

Fertilizer Production

The fertilizer plant produces single and triple superphosphates and a wide variety of formulations. Capacities permit the annual production of 43,800 tons of single superphosphate and 21,900 tons triple superphosphate. A notable feature of the Atlas Fertilizer Corporation scheme is the installation of a granulated mixed fertilizer plant which is

capable of producing any specialist formulation that may be required and has an annual capacity of 100,000 tons mixed fertilizers. The superphosphate used for mixing is, after curing for some two to three weeks, ground very finely and mixed in the required proportion with a variety of chemical salts such as urea, ammonium sulphate, muriate of potash, aqua ammonia, etc. After passing through the granulation plant there is a further curing period of about two weeks before material is ready for bagging.

Conclusion

The construction of the first major integrated fertilizer plant in the Philippines is a valuable addition to the country's expanding agricultural and industrial resources. Productivity from the land is very low, principally attributable to the traditional methods of cultivation of the land without replacing any of the plant foods. Fertilizers are scarcely used and it is estimated by the Bureau of Soils that only 23 Kgs. are used per hectare compared with 483 Kgs. in Japan and 548 Kgs. in Formosa.

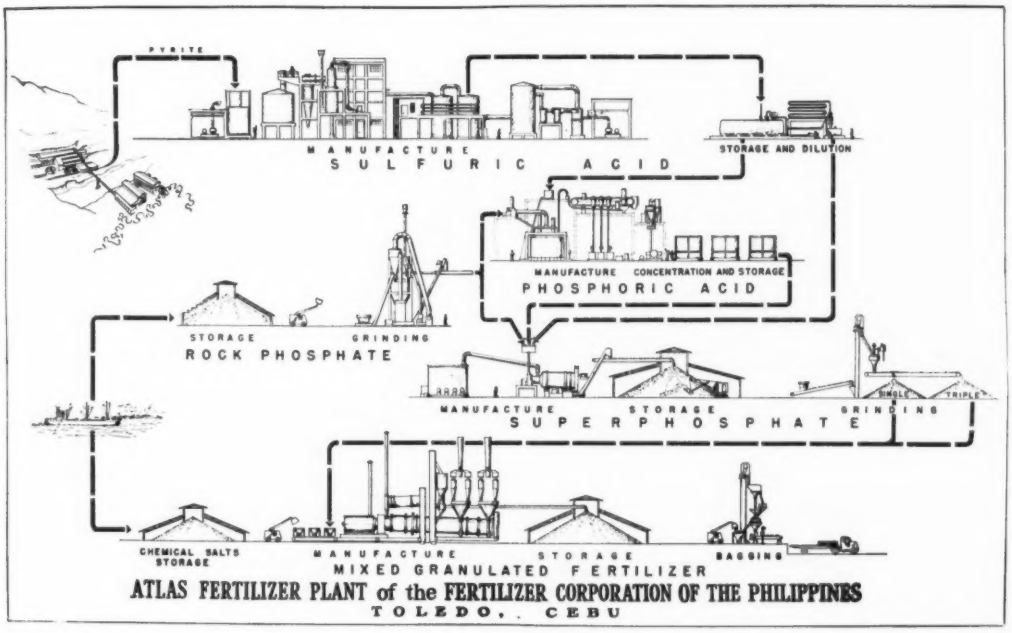


Fig. 12. Flow diagram.

The company expects to produce for domestic distribution 20,000 tons of single superphosphate, 6,500 tons of triple superphosphate and up to 100,000 tons of granulated mixed fertlizers. An important by-product is the arising of gypsum from the phosphoric acid plant at an annual rate of 30,000 tons which may be used on the soil as a stabilizer. At present the Philippine Republic is an importer of gypsum.

The new plant represents the first stage in the growth of a chemical fertilizers industry in the Philippines and, with the present Government support, consumption is likely to increase rapidly. This plant alone will save the country approximately U.S. $4.5 million in foreign exchange on fertilizers while the increased productivity from the land could lead to a reduction of some U.S. $30 million in rice imports.

THE GEELONG SULPHURIC ACID PLANT

THE PLANT INSTALLED at Geelong, South Australia, for the Shell Petroleum Co. Limited by Simon-Carves Limited and commissioned in November 1958 by Simon-Carves Australia (Pty.) Ltd., is designed to produce 100 tons per day of 100% sulphuric acid using either sulphur or H_2S gas. The plant is similar in many respects to a pyrites-burning sulphuric acid plant, in that the hot SO_2 gases are cooled, dried, and then heated before conversion to SO_3.

SO_2 Production

Sulphur is fed into a melting pit. This is of concrete and is divided into compartments for melting, settling and pumping, as with the usual sulphur-burning plant. From the pit, molten sulphur is pumped to a combustion chamber which serves for the combustion of both sulphur and hydrogen sulphide. The sulphur is sprayed into the combustion chamber by means of an air atomised sulphur spray gun. The hydrogen sulphide, which comes from the hydrofining plant on the refinery, is taken through a flame arrestor to the H_2S burners at one end of the combustion chamber. The combustion chamber is a horizontal cylindrical vessel lined with firebrick, and is on the suction side of the main blower so that the combustion air is introduced under suction. For preheating the combustion chamber during a plant start-up, a burner consuming refinery gas is used. The gas strength when burning hydrogen sulphide is approximately 8% SO_2 at the combustion chamber, and when burning sulphur this can be increased to 10-11% SO_2.

Cooling

The gases leave the burner chamber by a firebrick-lined duct to the waste heat boiler. The firetube boiler is designed for a working pressure of 300 p.s.i.g. and conforms to the Boiler Code of the Standards Association of Australia. Suitably treated and de-aerated feed water is supplied from elsewhere on the refinery. The boiler supplies saturated steam for all the acid plant requirements, including the sulphur melter coils and jacketted piping. The remainder of the steam passes to a superheater in the converter, then to a gas-fired superheater where it is superheated to refinery requirements.

The hot gases leaving the waste heat boiler must be further cooled and this is done by direct contact with weak acid in a packed gas cooling tower, which consists of a lead shell, supported by mild steel basketwork and lined with acid-resisting brickwork. The packing consists of acid-resisting ceramic rings. Weak acid returns from the cooling tower to a mild steel lead-lined tank which also receives the weak acid from the mist precipitator drains. The weak acid is pumped by a self-priming centrifugal pump from this tank through rack coolers of lead pipe before entering the tower. Weak acid formed in the cooling tower system is used for dilution of 99% acid at the strong acid circulation tank. While burning sulphur all of it can be used in this way, but when burning H_2S there is a surplus which goes to a neutralisation plant. The gas leaves at the top of the tower and passes through lead mains to the mist precipitators.

Precipitation and Cleaning

There are two mist precipitators in parallel, each consisting of a mild steel vessel, lined with lead. The moist gas flows downwards outside a number of vertical tubes, then upwards through the tubes, through which the electrodes hang. The precipitators are suitably elevated so that drip acid from them flows by gravity to the weak acid circulation tank.

The gases leaving the mist electroprecipitators pass through lead ducting to the drying tower. Passing upwards through the towers the gases are dried by a counter-current flow of 94% sulphuric acid. The tower is a mild steel vessel lined with acid-resisting brick and random packed with acid-resisting rings. The acid drains from the base of the tower to a circulation acid pump tank where a vertical-spindle submerged centrifugal pump delivers the acid through a series of rack coolers of cast iron pipe, up to the acid inlet near the top of the tower. Both the drying and absorbing acid coolers are in a concrete basin and are irrigated by sea water distributed from overhead troughs. To resist the corrosive action of sea water special protective measures have been taken which appear to be very satisfactory.

A centrifugal blower draws the air-SO_2 mixture through the combustion chamber, waste heat boiler, cooling tower, mist precipitators and drying tower and discharges through the oxidation and absorbing stages.

Conversion

Gas from the blower, having been cooled and dried, passes through the shell sides of the "cold," "intermediate" and "hot" heat exchangers where it is heated up to "ignition" temperature before entering the converter. The converter is of the four-pass type and is in effect four converters in one shell. The catalyst installed is Monsanto vanadium catalyst. In the first pass approximately 65-70% of the SO_2 is converted to SO_3, after which the gas passes to the "hot" heat exchanger, flowing counter-current to the incoming SO_2 gas before entering the second stage of the converter. A further 20-25% of the SO_2 is converted to SO_3 in the second pass before passing to the "intermediate" heat exchanger, where it is cooled before entering the third pass. Cooling between the third and fourth passes is by means of a superheater which is fed with steam from the waste heat boiler. The gas leaving the fourth pass enters the cold heat exchanger and is then further cooled in an SO_3 cooler before passing to the absorbing tower. The heat exchangers are of the shell and tube type and there is a system of bypass valves, on the SO_2 side, to give accurate temperature control and also to allow wide load variations. The final SO_3 cooler is also a tubular heat exchanger and the gas is cooled before entering the absorber by air supplied by a fan.

When starting up the plant it is necessary to heat the catalyst mass in the first pass of the converter to the "ignition" temperature by blowing hot air from a preheater through it. It is also necessary, until a high rate of conversion is established, to heat the SO_2 gas entering the converter by external means, as is the case for all cold gas plants. After that the process becomes autothermal at an adequate load and no external heat need be supplied. The preheater consists of a gas-fired furnace and a vertical tubular two-pass heat exchanger in which the air or gas is preheated on the tube side.

Absorption

After conversion and suitable cooling the gas enters the absorbing tower which is similar in size and construction to the drying tower and over which 98% sulphuric acid is circulated. The enriched 98% acid from the base of the tower flows to a 98% acid circulation tank and is recirculated over the tower through an acid cooler, the circulation system being similar to the drying acid system. The strengths and levels of the acid in the drying and absorbing acid circulation tanks are regulated by cross-bleeds between the two, by the addition of weak acid or water and by transferring the net 98% acid produced to disposal. The 98% product acid is cooled in a small rack cooler of cast iron pipe. The interconnecting piping in the strong acid circulation system is all in cast iron.

General view of the sulphuric acid plant at Geelong.

Effluents

All acidic effluents are neutralised before leaving the plant. Any excess make of weak acid is discharged from a lead tank to a batch tank which is formed of reinforced concrete, lined with acid-resisting brick. 15% spent caustic soda solution is used for neutralising and is mixed with the weak acid by a propellor

type mixing unit in the batch tank. After suitable mixing and testing, the effluent is discharged into a neutralising pit which is constructed of reinforced concrete lined with acid-resisting brick. The pit receives not only the effluent from the batch tank but also drainage from all acid areas and the waste water from the strong and weak acid coolers. The effluent flows over a limestone bed in the pit, then over a weir to a collecting chamber from which it is taken to the main refinery drain.

Conclusion

Apart from this plant, which is the first instance of sulphur content from H_2S being recovered at an oil refinery in Australia, a further development is the erection of a 40 tons per day sulphur recovery plant at the Altona refinery of Standard-Vacuum Refinery Company (Australia) Limited, which is due to enter production in 1960. These two plants form a valuable addition to domestic sources of sulphur and fully accord with Government policy of developing indigenous materials.

Filtration of Acid Mists and Fumes

A new fibre filter

AN EXTENSIVE programme of research by G. Lowrie Fairs, of the Imperial Chemical Industries General Chemicals Division culminated in the development of a new fibre filter which virtually eliminates the emission of very fine acid mist particles from the tail gases of major acid producing plants. The invention is the subject of patent application by Plaut and Fairs in the United Kingdom and in most countries abroad. Mancuna Engineering Limited of Denton, Manchester, have been granted a manufacturing and selling licence for the filter and are currently engaged in the detailed design of standard units and components.

The exceptional efficiency of the filtration achieved in this new filter is due to the employment, as the filter medium, of fine diameter fibres which possess hydrophobic characteristics. This characteristic results in the impingement on the fibres of discreet droplets of very fine liquid particles and in a very free dispersion and drainage of liquid through the mass of fibre. The experimental work has been carried out primarily with glass fibre and Terylene.

In the case of glass fibre it is necessary to treat the fibre with a silicone such as I.C.I. Silicone M441 in order to provide the hydrophobic characteristics on which the operation of the filter depends. A 2" thick pad is formed either in the shape of a flat disc or in candle form ; the pad being moulded at a temperature in the range of 400/550°C. In the case of Terylene the effective temperature is in the range of 140/160°C. Packing in the formation of the mould, and careful handling, are essential to prevent folds in the final filter pad, which, if not obviated, could cause channelling of the mist-laden gas and consequent deterioration of efficiency.

The filters have been extensively tested at pilot plant stage in the elimination of mist from gases containing very fine sulphuric acid mist. The performance where the acid mist comprises droplets which are 100% below two microns has been such that an inlet concentration of 0.1 g. H_2SO_4/M^3 has been reduced to an emission to atmosphere of a mist concentration of 0.0005/0.0007 g. H_2SO_4/M^3. A very significant feature of this equipment is that the emission of mists from the outlet of the filter does not increase where there is a temporary or fluctuating increase in the inlet concentration. This self-compensating characteristic over a wide range of gas flow rate and mist concentration is a revolutionary feature of filtration equipment of this kind and is clearly of the greatest significance.

For the assessment of a mist emission problem special sampling methods have been devised to determine the particle size distribution on which is determined the packing density required in the pre-forming of the filter elements.

One proposed design of unit being engineered by Mancuna is illustrated in

Fig. 13 which shows an assembly of pre-formed filter candles. Mancuna are concentrating on the application of Terylene fibres as the filter medium, the Terylene fibre being very resistant to normal acid conditions met in tail gas emissions, and providing certain process advantages in that no silicone treatment is required, the Terylene fibre being intrinsically hydrophobic.

The unit as illustrated comprises an assembly of blocks of standard filter candles each consisting of six 10″ long elements sealed together to form one composite candle. Inclusive of the steel tank and top outlet chamber the unit will stand approximately 6′ 0″ high though some 13′ 0″ of headroom will be necessary to permit the withdrawal of

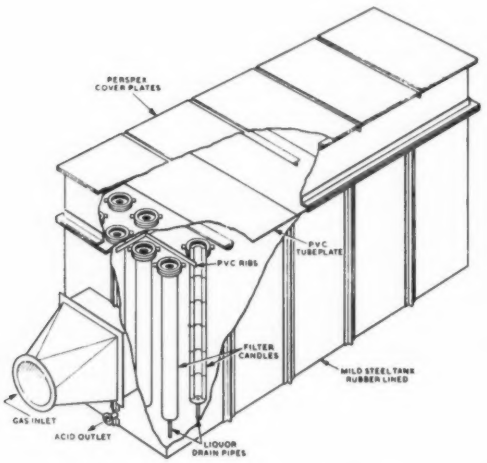


Fig. 13. Cut-away diagram of fibre filter.

the candles for any necessary servicing or replacement. It is intended that units should be introduced into existing plant through ducts which will incorporate " U " bends which can be used as individual water seals. The liquid removed from the gas discharges down the centre core of the candle and is removed from the tank through a simple acid outlet as is illustrated. Should there be any breakdown in one or other of the candles, mist channelling through the filter pad into the centre core of the candle will be clearly visible through the perspex cover plates. Should such an event occur the unit can be isolated by flooding with water prior to the safe removal of the candles for inspection and/or replacement.

It is anticipated that one candle of six elements with a 10″ w.g. pressure drop will handle some 200 cubic feet of air per minute. A period of up to 24 hours is required from the start-up of the filter before maximum efficiency is achieved owing to the necessity to build up an adequate liquor content in the fibres.

In addition to its use in sulphuric acid manufacture a number of other applications are envisaged. The unit as illustrated and described above is to be sold under the trade name Mancuna-Mistex while a further irrigated form of the filter will be sold under the trade name Mancuna-Fumex. The application of the irrigated form of the fibre filter will permit the recovery of mists where the acid concentration would normally be such as to damage the filter medium. A further significant potential is that very fine fumes which can be physically dissolved, emulsified or dispersed, or form a colloidal suspension in liquid, can be eliminated from a gas stream with remarkably high efficiency. As an indication of the performance of the Mancuna-Fumex Fibre Filter in its application to fume removal a pilot plant employing Terylene polyester fibre pre-formed into a flat cylindrical mat where the filter medium was continuously irrigated with water was applied to a fume containing fine particles of sodium monoxide, together with calcium chloride, sodium chloride and chlorine. This fume was obtained in the replacement of diaphragms in cells for the electrolysis of fused mixtures of sodium chloride and calcium chloride. The top particle size of the contaminating particles was less than $4\frac{1}{2}$ microns, 90% by weight being less than $3\frac{1}{2}$ microns and 50% by weight being less than 2 microns. The concentration of particles in the fume varied between 0.25 and 1 g./m^3 of air. The filter was applied to remove this fume for a period of two months with no detectable amount of solid found in the exit gas—any solid present in the exit gas being present in quantities certainly less than 0.001 g./m^3.

Company Reports

Texas Gulf Sulphur Company

IN THEIR ANNUAL REPORT the Chairman, Mr. Fred M. Nelson, and the President, Mr. Claude O. Stephens, reported that although sales reviews and earnings of the Texas Gulf Sulphur Company in 1958 were below the levels achieved in 1957, the pattern of business was mixed and the year ended on an encouraging note.

Sales

The company's sales in 1958 amounted to $57.1 million, $9.8 million less than in 1957. Sales in the first six months were particularly affected by the lower industrial demand for sulphur resulting from the general recession. However, with the beginning of the third quarter, consumers once again started to expand their operations, with the result that gross sales for the company in the fourth quarter were in excess of the same period in 1957.

In the middle of the year Texas Gulf Sulphur Company formed, in conjunction with three other U.S. Frasch producers, The Sulphur Export Corporation, and as a result strengthened the sale of sulphur overseas.

Production

1958 marked the production of the 50 millionth ton of sulphur from the Boling Dome which began production on the 20th March, 1929. As a measure of their progress since that date it is interesting to note that the Texas Gulf Sulphur Company's operations to-day include Frasch mines at Moss Bluff, Spindletop, and Fannett in Texas, and Nopalapa in Mexico, sour gas recovery plants at Worland, Wyoming, and Okotoks, Alberta, and direct electrolysis of nickel matte in conjunction with International Nickel Company at Sudbury, Ontario.

Despite this progress, however, Texas Gulf Sulphur Company produced only 2.2 million long tons of sulphur in the United States in 1958, a reduction of 25% below the 1957 level. 60,000 tons of sulphur were produced at Worland and at Nopalapa in Mexico approximately 115,000 tons were extracted.

Stocks

During 1958 stocks of the company's sulphur both in the United States and Mexico were estimated to be 3,150,000 tons, an increase of approximately 5% over 1957.

Reserves and Research

During the year the company has continued to intensify its research with particular attention to sulphur recovery projects and to further its exploratory programme throughout the world. Amongst the research that was carried out was the evaluation on a pilot plant scale of new methods in the purification of "dark" sulphur and a new process for the treatment of waste water from sulphur mining operations to prevent stream pollution. In

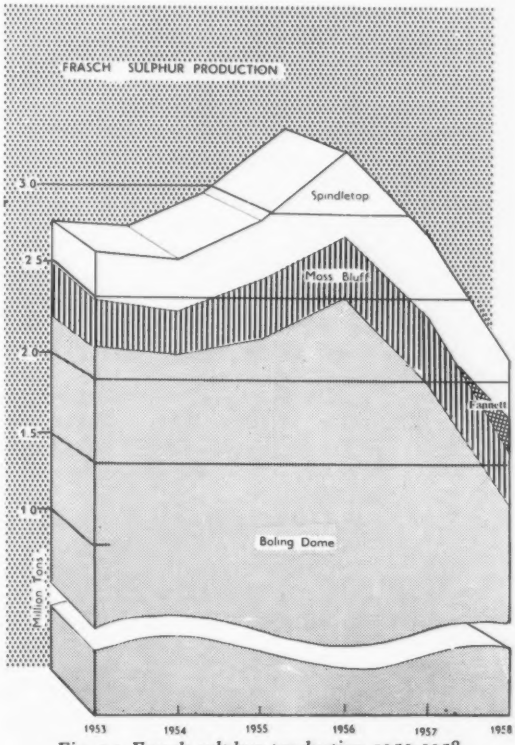


Fig. 14. Frasch sulphur production 1953-1958.

co-operation with International Nickel Company of Canada Limited, a pilot plant, designed to yield engineering data on the improved process of recovering sulphur from smelter gases, was completed in 1958 at Sudbury, Ontario.

Personnel

On November 25th 1958, as a result of a change in the company's by-laws which raised the Board of Directors to 11, Mr. Leslie M. Cassidy, Mr. John A. Hill and Mr. Allan Chivers were elected to the Board. Mr. Cassidy occupies a senior executive position within the Johns-Manville Corporation and Mr. Hill is president of the Air Reduction Company Inc., and Mr. Chivers, who was once Governor of Texas, is at present Chairman of Western Pipelines Inc. In addition to this appointment Mr. H. S. Caven, Director of Public Relations for the company in Houston, Texas, and Mr. A. N. Myers, manager of Sales in New York, have been mentioned as new Vice-Presidents.

Finance

Net earnings from sales declined to $13.4 million, a decrease of $4.1 million (23½%) compared with 1957. Dividend was again reduced and in 1958 $1.34 was paid per share as compared with $1.75 in 1957. Total assets increased by 3% to $120.1 million, mainly the result of increased stocks above ground ; these once again rose and in 1958 were estimated to be $32.9 million, an increase of $5.3 million (19%) over 1957.

Policy

In the report the Chairman laid particular emphasis on the necessity for the Texas Gulf Sulphur Company to expand their sulphur interests in view of the steady growth projected for sulphur consumption in the years ahead. To implement this policy the company would continue to direct their energies to the investigation and exploitation of not only new reserves of Frasch sulphur, but also in the realms of metallic sulphides and gas-recovered sulphur. He stated, as illustration of this policy, that the sour gas sulphur recovery plant at Worland, Wyoming, produced approximately 60,000 tons of sulphur in 1958, whilst a similar recovery plant at Okotoks, near Calgary, Alberta, is expected to come on stream in the summer of 1959 with an annual capacity of 100,000 tons of sulphur.

Conclusion

The Texas Gulf Sulphur Company was hit by the general recession in the early part of 1958 and as a result increased their stocks above ground. However, as from the beginning of last quarter the company have been able to expand their operations again and the Board of Directors of the company feel that progress will continue to be made in 1959. They claim, moreover, that the need for expansion remains as sulphur consumption will continue to increase and, despite the increasing impact that the new production of sulphur in Mexico, France and Canada is having, and will continue to have, upon the supply situation, that a balance of sulphur supply and demand will eventually be effected.

Freeport Sulphur Company

THE REPORT OF THE BOARD OF DIRECTORS, presented by the Chairman, Mr. Langbourne M. Williams, and the President, Mr. Charles A. Wight, states that, as a result of the recession at home, Freeports' tonnage sales in the United States were below the level of the previous year but that this decline was partially offset by an increase in overseas sales. Overall demand accordingly sustained sales and production at a relatively high rate of approximately 2 million tons.

To meet more effectively the increased competition abroad from foreign sources the company participated with three other domestic Frasch producers in the formation of the Sulphur Export Corporation (SULEXCO) and are selling their sulphur through this organization to consumers in all foreign countries except Canada, Cuba and Mexico.

Mr. Williams said that in the sulphur industry, as in all basic raw materials industries where the creation of new capacity is a matter

of many years, the producer must acquire his reserves for the future as they become available, planning not on temporary fluctuations in supply and demand but on long-term trends in the market. It is this long-range need for sulphur which dictates the acquisition and development of deposits like the Grand Isle offshore property and the company's other mine at Lake Pelto on the Louisiana coast—both of which were under construction during 1958.

Whilst appreciating the threat of competition from Mexico, France and Canada, and therefore excess of supply over demand, the Board of Directors expressed themselves well equipped to compete during the period of

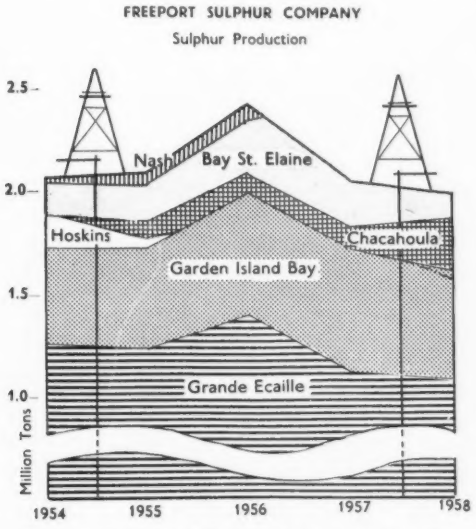


Fig. 15. Frasch sulphur production 1954-1958.

surplus and remained confident that continued growth in population, fertilizer use and in the chemical industry will eventually supply the necessary demand for the increased production of sulphur.

Other Activities

Nickel and Cobalt. Despite the civil strife in Cuba during the year construction of facilities for the extraction of nickel and cobalt from Cuban ores at Moa Bay continued to progress and the plant is expected to be completed later this year. The second half of the project at Port Nickel, Louisiana, will have an annual capacity of 50 million lbs. of nickel metal, 4.4 million lbs. of cobalt metal, in addition to the production of 90,000 tons annually of ammonium sulphate arising as a by-product.

During the year the name of the operating subsidiary was changed from Cuban American Nickel Company to Freeport Nickel Company. The Moa Bay Mining Company will continue to operate the Cuban facilities.

Oil and Gas. On October 31st 1958 Freeport Sulphur Company sold to Magnolia Petroleum Company Limited their oil and gas interest in the Lake Washington field in Louisiana for $99.45 million. The net cash proceeds from the sale, after provision for capital gains and other taxes, amount to approximately $74 million.

This sale of a major part of the company's operating division, Freeport Oil Company, in no way diminishes the company's wish to expand in this field, and it is intended to devote earnings from oil and gas sales for the furtherance of this programme.

Potash. In 1958 National Potash Company, which is jointly owned by Freeport and Consolidation Coal Company, completed its first full year of production at its mining and processing facilities near Carlsbad, New Mexico. In December, National Potash entered into long-term sales agreements which should favourably affect its sales volume and hasten the time at which that company can achieve a profit position. The agreements will also result in the development of some of National Potash's additional reserves in either New Mexico or Canada.

Finance

Sales once again declined and at $55.3 million were the lowest since 1953. However, net earnings increased fractionally to $13.1 million or $5.23 per share on the 2.5 million shares of common stock outstanding at the end of the year. These earnings do not include a non-recurring profit after taxes of $67.1 million or $26.81 per share, from the sale of the Lake Washington interests. This profit was added directly to earnings retained in the business. Dividend payments in 1958 again amounted to $3.00 per share. In January 1959 the regular

quarterly dividend was increased from 75 cents to 90 cents per share.

As a result of the Lake Washington sale, total assets rose from $93.8 million to $164.5 million. Stocks of sulphur again decreased, and in 1958 were valued at $8.4 million, a decline of 14%. Fixed assets rose by $10 million to $51.3 million mainly as a result of the completion of major constructional work at Grand Isle, Lake Pelto and Moa Bay.

Conclusion

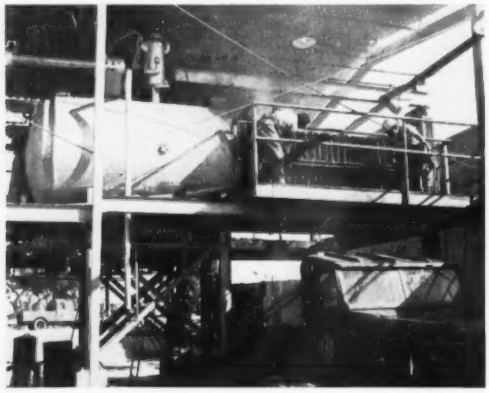
Summing up, the Chairman stated: "It has been difficult to reflect in our annual reports the real progress we have made in the acquisition of valuable mineral reserves. In a mining company like Freeport, reserves underground constitute the most important of our corporate assets. We have consistently been pursuing a policy of adding to our reserves, but the standard accounting procedures which we follow do not always show currently in terms of dollars and cents what is being accomplished.

"For example, our oil and gas programme, in seven of the eleven years since its inauguration, has reduced the reported over-all earnings of the company. Yet the gradual build-up of our reserves of oil and gas during this period enabled us eventually to sell our interests at Lake Washington for a profit which was equal, after taxes, to nearly $27 per share of common stock outstanding. The profit from this sale was placed in the category of earnings retained in the business and was not reported as current earnings.

"From the proceeds, we have repaid a loan of $6,500,000 drawn against the $25,000,000 bank credit described in last year's report, and this credit agreement has been terminated. With our investment in the nickel-cobalt project already completed and with the financing of the Grand Isle and Lake Pelto sulphur developments provided for, the sale gives Freeport a current cash position, in excess of working capital requirements, of more than $50,000,000. This strong cash position will enable us to take advantage of new opportunities to expand our current activities and to diversify into other fields as we have in the past."

Pan American Sulphur Company

PRESENTING THE COMPANY'S REPORT FOR 1958, the third year of full operations, the President of the Pan American Sulphur Company, Mr. Harry C. Webb, reported continued progress and development. Results for the year showed an important advance over 1957, and the continued growth of sulphur production is anticipated.



Pan American Sulphur Company. Cleaning of Filtration unit.

Sales

Total sales of sulphur during 1958 amounted to $17,318,113 compared with $15,696,558 in 1957. Shipments of over 800,000 tons during 1958 showed an increase of 122,000 tons (18%) over 1957. These results were achieved despite severe competition, generally lower prices and continued over-supply of product. The year's results raised total sales since the company's inception in 1954 to 2,038,000 tons.

Production and Stocks

Apart from a new recreational and educational centre which is being built for the use of both employees and townspeople at Jaltipan,

no new major construction work took place during the year. Continued increases in the rate of output resulted in the production of over 800,000 tons of sulphur, an increase of over 50,000 tons (7%) over 1957. This production raised the total tonnage produced since the commencement of operations in 1954 to 2,590,000 long tons.

Stocks as at 31st December 1958 stood at 552,000 tons, an increase of 14,000 tons (2.6%) over 1957. Mr. Webb stated, however, that this tonnage was not sufficient to cover a single year's requirements, based upon annual consumption during the last three years. He anticipates in this connection that the company will produce in excess of 800,000 tons during 1959.

Finance

Net income during 1958 amounted to $3,575,032 compared with $3,452,555 in 1956, an increase of 3.5%. Net income per share was affected by the increase in the number of shares from 2,044,921 in 1957 to 2,119,417 as at 31st December 1958 and thus remained steady at $1.69.

Mr. Webb reported continued improvement in the working capital and cash position of the company after providing for sinking fund requirements on the company's debentures and instalments on the Export-Import Bank notes maturing in 1959. The net cash flow of $4,664,403 was utilized to :—

(i) reduce indebtedness to the Export-Import Bank by $760,667,

(ii) provide $323,200 for 1959 sinking fund requirements on the company's debentures,

(iii) pay cash dividends of 80 cents per share or a total of $1,687,034,

(iv) subsidise maintenance totalling $118,527,

(v) to increase working capital and prepaid expenses by $1,774,975.

After the regular semi-annual principal payment made on the Export-Import Bank notes in February 1959 the long-term indebtedness of the company (including current instalments) was reduced to $6,140,033, consisting of the balance of the Export-Import Bank notes of $1,521,333 and outstanding debentures of $4,618,700. Book value of fixed assets at the end of 1958 amounted to $10,441,554 as against $10,942,280 in the previous year.

At the regular quarterly meeting held at their new offices in Houston on February 18th 1959, the Board of Directors increased the regular quarterly dividend from 20 cents to 25 cents per share and, in addition, authorized payment of a 2% stock dividend, both payable on March 31st 1959 to those holding shares on February 27th 1959.

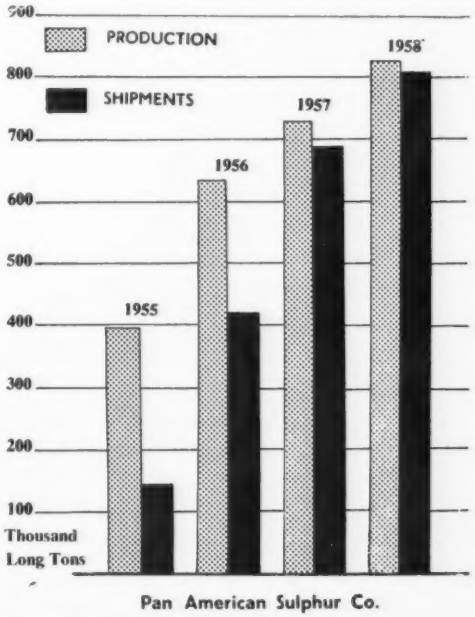


Fig. 16. Sulphur production and shipments 1955-1958.

Conclusion

The President declared that satisfactory progress had been made during the year, and he anticipated that sales for 1959 would approximate those of the past year. However, he stated that long-range projections were unusually bright due to the continued industrial development throughout the world, increased requirements and demands for fertilizers and the general expansion of the world's chemical industry.

Current Events

AUSTRALIA

Additional Capacity at Risdon

The Electrolytic Zinc Company of Australasia Ltd., commissioned its third contact sulphuric acid plant at Risdon in the latter half of 1958. Announcing this in his company's annual report, Mr. H. Hey, Chairman of the Board of Directors, states that the company now has capacity to produce annually 170,000 tons of sulphuric acid (100% H_2SO_4). All-round progress in the company's affairs is reported, in particular zinc production rose 8% to 115,129 tons.

For the year ended June 30th 1958 sulphuric acid produced at Risdon totalled 111,905 tons, all of which is recovered from the SO_2 arising from roasting zinc concentrates, an increase of 17,000 tons compared with the previous year. Superphosphate production rose to a record total of 104,700 tons (+27¾%) and sulphate of ammonia to 49,748 tons (+27%). The company's own manufacture of superphosphate consumed 36,000 tons of acid and ammonium sulphate production required 38,000 tons; the remainder was consumed in Tasmania except for 2,800 tons which were shipped to New South Wales.

The record production of fertilizers has been attributable to the additions in the superphosphate plant's capacity and in the case of ammonium sulphate, to an abundant supply of power, thus allowing the plant to be worked to capacity most of the year. Sales of ammonium sulphate totalled 44,800 tons of which approximately 87% was shipped to Queensland. An interesting development has been a trial bulk shipment to Queensland and, as it was found that there was a considerable saving in handling, it is planned that where possible future shipments will be made in this way.

CANADA

Sulphur in Alberta 1958

The commissioning of *British American Oil Company's* additional two sulphur recovery units in the autumn of 1958 at Pincher Creek, contributed to the company's record production of recovered brimstone of 77,296 short tons, which compared with 58,624 short tons in the previous year, is again the largest sulphur operation in W. Canada. Total production of elemental sulphur in Alberta in 1958 was 122,326 tons, an increase of 22% over the previous year. *Shell Oil Company*, of Canada, operating a plant at Jumping Pound, produced 32,325 short tons, an increase of 4,400 tons compared with 1957, whereas the remaining two producers, namely *Imperial Oil Company* at Redwater and the *Royalite Oil Company* at Turner Valley, both reported a decrease in production of −30% to 1,732 tons and −12½% to 10,343 tons respectively.

Total sales of sulphur reported by the four manufacturers reached 91,533 tons, about 2,000 tons less than the previous year, whilst some 26,955 tons were added to inventories. The scope of the W. Canadian sulphur market has not yet changed and sales are directed to the local consuming industries, notably Northwest Nitro Chemicals at Medicine Hat, Gunnar Mines Limited at Uranium City, and the pulp and paper industry in British Columbia. Rail freights at present 60 cents per 100lbs. from Alberta to Vancouver, mitigate against exports and penetration into the Great Lakes market.

Noranda Process Abandoned

In February, after more than four years' production, *Noranda Mines Ltd.* suspended all activities at their Port Robinson, Ontario, plant which was equipped to roast pyrites by the company's special process in which the free sulphur molecule was recovered in elemental form and the pyritic sulphur burnt to sulphur dioxide for sulphuric acid manufacture, whilst the residue accrued as high grade iron sinter.

The decision to cease operations was taken in view of the adverse economics now that brimstone in Canada is abundant, and its price about one-third lower than at the time the plant was commissioned. It was designed to roast daily 370 tons pyrites concentrates originating from the company's West McDonald Mine and to yield 62 tons brimstone for supply mainly to wood pulp and

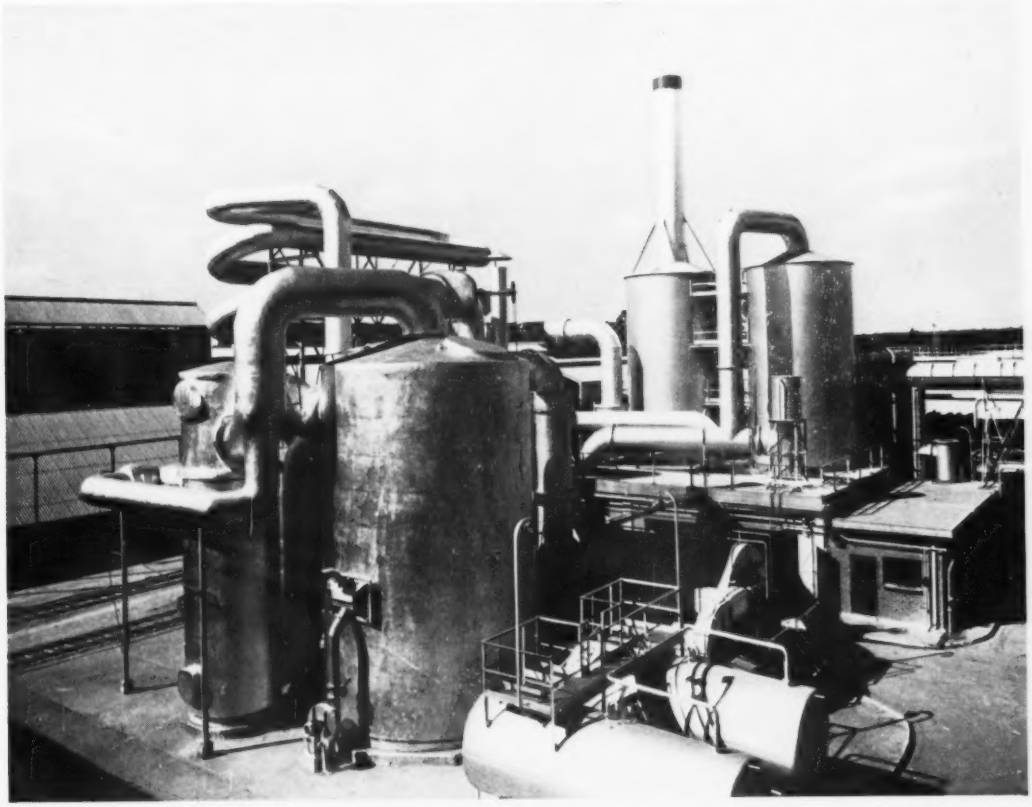
paper producers, 240 tons SO_2 as 7% gas for conversion to sulphuric acid in the adjacent plant of Cyanamid of Canada Limited and 250 tons iron sinter. In 1957, probably the plant's most active period, 44,000 tons pyrites concentrates were roasted, resulting in the production of 2,400 tons brimstone, 30,000 tons SO_2 gas and 39,000 tons of sinter. Now that this source of sulphur supply is no longer available, Cyanamid of Canada Limited has reverted to using exclusively brimstone.

At the two sulphuric acid plants of Noranda Mines Ltd. at Cutler, which supply the needs of the Blind River area for uranium ore leaching, pyrites continue to be used, but operations are not designed to recover brimstone and the entire sulphur content is conventionally roasted to SO_2.

SOUTHERN RHODESIA

New Fertilizer Plant in Operation

African Explosives & Chemicals Industries (Rhodesia) Limited commenced production in February at their new Rhodia fertilizer factory at Salisbury, Southern Rhodesia. The plant has an annual capacity of 60,000 tons triple superphosphate and obtains the required sulphuric acid supplies from an integrated 184 tons per day (100% H_2SO_4) plant. Built by Simon-Carves Limited, the acid installation is based on the contact process and uses indigenous pyrites originating from the Iron Duke Mine near Glendale. The single and triple superphosphate capacity of the plant is estimated to be sufficient to meet the needs of the Central African Federation for many years to come, thus ending these territories' dependence on



General view of recently completed sulphuric acid plant at Rhodia.

imports. This drive for self-sufficiency has been extended to aluminium sulphate and African Explosives & Chemicals Industries plan to erect a £85,000 plant at Mazoe, near Salisbury, for the manufacture of this chemical to meet the needs of water purification.

U.S.A.

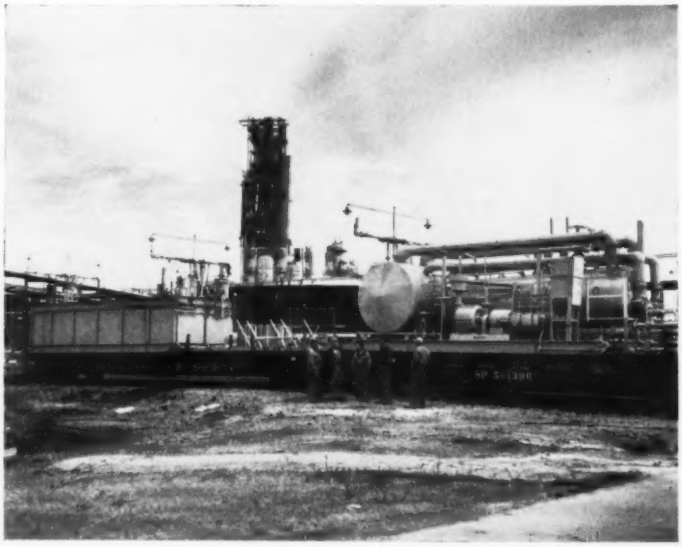
Liquid Sulphur Shipments by Texas Gulf Sulphur Company

The decision to construct a liquid sulphur terminal at Tampa, Florida, was taken, Mr. Claude O. Stephens, President of Texas Gulf Sulphur Company, said in a recent announcement, "*because trend in our industry is toward the greater use of molten sulphur.*" The company is conducting the appropriate development work in conjunction with the DeBardeleben Marine Corporation of New Orleans. Starting in August, liquid sulphur will be shipped in a Liberty vessel, specially converted by DeBardeleben, from the rebuilt Neches River Marine terminal of Texas Gulf Sulphur Company near Beaumont, Texas, to the DeBardeleben terminal at Tampa. The vessel will be equipped with steam heated tanks with a total carrying capacity of 7,500 tons sulphur. This project is integrated with the major reconstruction taking place at Neches River which, at an estimated cost of $3 million, will include dredging a channel, and the construction of a turning basin, docks and other facilities which will permit better handling of solid sulphur as well as liquid sulphur shipments. The U.S. Army Corps of Engineers, the responsible authority for all matters affecting inland waterways, have granted the requisite permit and Texas Gulf Sulphur Company has entrusted the contract to Standard Dredging Corporation of Galveston, with Brown & Rout Inc. of Houston as engineers.

The plans provide for a 3,600ft. long canal dredged to a depth of 36ft. able to accommodate 15,000-ton vessels, to link the Neches River with the company's storage area, where the turning basin is to be built. The storage area serves Spindletop dome and will also be the main outlet for the new Fannett dome, 15 miles distant. The new project is sited wholly within the company's own property. Texas Gulf Sulphur Company has done much pioneering work on barge movement of liquid sulphur, and this form of sulphur transport was introduced at the Neches River terminal only in April 1958, when a two-barge train departed with some 5,000 tons in molten form. The introduction of ocean-going vessels opens new prospects which, in the highly competitive state of the market, should stand the company in good stead.

Sulphur Recovery

At their Toledo, Ohio oil refinery the *Sun Oil Company*, of Philadelphia, recently installed a Tears type skid-mounted sulphur recovery plant.* Tears Engineers Limited of Dallas, Texas, acting as licencees of the Pan-American Petroleum Corporation developed this design specifically for the recovery of sulphur from small volume emissions of H_2S. The plant at Toledo, which cost $150,000, has an annual rated capacity of 2,750 tons high purity brimstone. The plant incorporates



Sun Oil Company. Arrival of complete sulphur recovery plant on two rail trucks at Toledo refinery prior to erection. Sulphur storage tank on left.

* See Special Issue published in 1958.

several novel design features mainly with regard to gas circulation and heat recovery, but the recovery process remains essentially based on the principles of the Claus kiln in which hydrogen sulphide gas extracted from the oil refinery gas stream is burnt to sulphur dioxide, which in the presence of a bauxite catalyst is then converted to elemental sulphur. According to the first operation report by Sun Oil Company the plant, despite the modest design rate of only 8.3 tons per day, is capable of producing up to 12.5 tons daily and has in fact produced in excess of 13 tons during the initial 36 hours operation. Under the variable conditions of oil refinery operations this wide measure of flexibility is a considerable asset.

The Anlin Company of Illinois, a subsidiary of the Anlin Company headquartered at Houston, Texas, have commenced the construction of a 150 tons per day sulphur recovery plant at Wood River, Illinois. The plant, which is to cost in excess of $1.75 million, is being built by Industrial Gencon Incorporated of Houston, on a 12-acre site adjoining the oil refinery belonging to the Shell Oil Company. Built to utilize the resultant refinery fuel gases, the sulphur recovery plant will come on stream in July 1959.

The plant will be based on a process developed by the Anlin Company for its 35-ton per day sulphur recovery plant operating at Perth Amboy N.J., in conjunction with the California Oil Company. The process employs diethanolamine as an absorbing agent and the conventional two stages of conversion and scrubbing. In conjunction with the sulphur recovery plant, the Anlin Company will use and operate a reactivator plant section to strip H_2S from the amine solution and return the stripped solution for reabsorption to the Shell Oil refinery.

Major New Sulphuric Acid Project in Delaware

Dixon Chemical Industries Inc. of Bloomfield, New Jersey, has commenced construction of a sludge burning sulphuric acid installation at the plant site of the I. P. Thomas Division in Paulboro, New Jersey, where the company manufactures triple superphosphate. The acid plant, which has a rated capacity of 300,000 tons (100% H_2SO_4) per year is designed to produce all strengths of sulphuric acid, including electrolyte acid and to use as sulphurous raw material sludge acid, alkylation spent acid, sulphuric acid wastes, high sulphur content organic waste, as well as various grades of brimstone. The plant installations include facilities for the receipt of all raw materials, and in addition to normal lorry and rail transport the company is also completing arrangements for the construction of a 2,000 tons acid barge which, divided into separate compartments, is capable of carrying at full capacity virgin and spent acid without one contaminating the other.

The plant which is being built by the Chemical Construction Corporation of New York under the supervision of Singmaster and Breyer of New York, who are acting as consultants to Dixon Chemicals, is expected to be ready for operation in September. It will be the first sulphuric acid plant to be built in the Delaware Valley, specifically designed to serve the oil refining industry and others who have spent acid for disposal.

The Development of the Chemical Industry at St. Paul, Minnesota

The development of the Roseport Industrial District, built on a 6,250-acre site 12 miles south of St. Paul, Minn., has been rapid and spectacular since 1954 when the first installation, an oil refinery with a daily capacity of 10,000 barrels, was built. Since then investment of some $56 million has brought, in addition to oil refineries, many branches of chemical industry to this centre.

One of the most recent additions is a sulphuric acid project which was the direct result of regional market investigations by the First National Bank of St. Paul, and the Northern States Power Company. This survey proved conclusively that there was a need for the establishment of a sulphuric acid plant and, as a result, *North Star Chemicals Inc.* was formed for the purpose of building and operating a plant at Pine Bend, near St. Paul. The new company is controlled by Mr. Robert Campbell, of Vancouver, British Columbia, who also owns a majority interest in Inland Chemicals Inc. of Alberta, Canada, and St. Paul Ammonia Products Inc.

Due for completion in the early autumn, the new plant has been planned with an annual capacity of 80,000 tons (100% H_2SO_4) to allow for the expected expansion of current sulphuric acid demand which has been estimated at 50,000 tons, represented by some 51 consuming companies in the area. The plant is to have a nominal capacity of 200 tons per day (100% H_2SO_4) virgin acid with provision to reclaim an additional 50 tons per day of sludge. It has been designed, and the equipment will be supplied, by the Titlestad Corporation of New York City and construction will be undertaken by Quamco Inc., of Vancouver B.C. and St. Paul, Minn. The plant's brimstone requirements, expected to rise rapidly to 65 tons per day, are assured. There are local supplies of up to 60 tons per day of recovered sulphur available in molten form at the adjacent refinery of the Gt. Northern Oil Company which, it is expected, may expand capacity to 140 tons per day by 1961. North Western Refining is considering the installation of sulphur recovery facilities, which at their present rates of oil production would produce approximately 20 tons of sulphur daily. Another potential source is the Signal Oil & Gas Company who recover between 40 and 50 tons daily of sulphur from natural gas at their plant at Tioga, N. Dakota, whence it can be moved by rail to St. Paul at $9.20 per ton. Sulphur supplies from the Gulf Coast could be brought by barge up the Mississippi to Pine Bend where river frontage is available.

In the opinion of local industrialists, at least $1 billion will have been invested in plants in the St. Paul area by 1963, and the Roseport Industrial District will have become one of the largest chemical production centres in the United States.

Renewal of Contract

Duval Sulphur & Potash Company and *Ashcraft-Wilkinson Company* have recently extended the contract under which Ashcraft-Wilkinson Company represents Duval as its exclusive sales agent for potash and domestic sulphur.

This agency agreement commenced when Duval entered the sulphur industry some thirty years ago and has continued uninterrupted through the years. In 1950, the agreement was expanded to include Duval's production of Muriate of Potash.

MEXICO

New Sulphur Storage at Tampa for Pan American Sulphur Company

In a recent statement Mr. Harry C. Webb, the President of *Pan-American Sulphur Company*, announced the decision to start immediately on the construction of a $500,000 dry bulk and liquid sulphur storage facility at Tampa, Florida. The Company has entered into a long-term lease agreement with Port Sutton Inc., for part of the latters Black Point property. The storage facilities will be capable of handling some 300,000 tons of dry bulk and liquid material annually and at any one time will accommodate some 65,000 tons. Transport facilities from this new sulphur terminal will be by rail and road. According to the design and engineering programme the plant will be completed in July, 1959.

The object of the project, Mr. Webb emphasised, was to improve the company's service to customers and have adequate tonnage on hand to meet the market in the area which in 1958 totalled some 200,000 tons and to improve the quality of supplies.

NORWAY

Integration of Activities

Aktieselskapet Borregard, Norway's largest rayon and cellulose manufacturer acquired early in 1959 all the assets of Folldal Verk A/S. This mining company produced 39,500 tons pyrites in 1958 from the beneficiation of some 82,000 tons ore, which also yielded 3,000 tons zinc blende, 3,300 tons copper concentrates, 1,500lbs. silver and 27lbs. gold. The output of pyrites in 1958 shows a substantial decrease compared with the record production of 1956 when 46,201 tons were produced.

No change in policy is reported in respect of pyrites mining and supply and the whole output will continue to be shipped to the cellulose plant of the parent company at Sarpsborg where it is used to manufacture sulphur dioxide for the production of sulphate and rayon grade pulp and for sulphuric acid production. Consumption of pyrites will be subject to fluctuations in staple fibre manufacture but it is anticipated to remain at about 40-45,000

tons annually. The acid plant which was commissioned in 1954 has an annual capacity of 25,000 tons (100% H_2SO_4). A/S Borregard also consume about 4,000-5,000 tons brimstone in the manufacture of CS_2 and supplies are met from domestic sources although they are reported to be considering purchasing material from European sulphur producers or supplies from the Gulf of Mexico.

POLAND

Sulphur and Sulphuric Acid

The first stage of the construction of the Piaszeczno sulphur mine has been completed and the administration of the mine is reported to have been handed over to the Tarnobrzeg sulphur works. It is intended to produce 150,000 tons of ore during 1959, rising to 350,000 tons by 1965.

Meanwhile consideration is being given to the construction of a second sulphur mine at Solec, near Kielce, where more shallow deposits have been recently discovered. It was originally intended to construct the second mine at Machow, but it is now claimed that by building at Solec, considerable savings would be made. The Machow project appears to have been postponed.

The first sulphuric acid made from Polish brimstone has been produced at the Ubocz fertilizer works in Lower Silesia. The product is said to be in no way inferior to that made from sulphur imported from China, Poland's principal source of supply. The sulphuric acid plant at Walbrzych will also begin to consume Polish sulphur within the next few months.

Whilst these activities at Ubocz and Walbrazych are mainly by way of experiment, the first Polish sulphuric acid plant to be exclusively based on the new sulphur deposits is being constructed with French aid, at Torun, as part of the phosphate fertilizer works. This plant, which is being built primarily as a pilot plant for future acid installations based on Polish brimstone, will come on stream in 1959 with an annual capacity of 100,000 tons of 100% H_2SO_4.

The construction of the superphosphate factory has begun at Machow in the Rzeszow District. The plant is to be built in two stages and it is foreseen that production will reach 100,000 tons by 1961, whilst the second stage, raising it to 500,000 tons is expected to be achieved by 1965.

SPAIN

By-product Acid Plant at Minas de Rio Tinto

Compañia Española de Minas de Rio Tinto smelt cupreous pyrites by the Orkla process for the production of copper matte and elemental sulphur. The smelter exit gases contain up to 100 grams of sulphur per cu. metre and, whilst in the past this has been allowed to be exhausted to the atmosphere, it is now proposed to utilise the sulphur content of these waste gases for the manufacture of sulphuric acid. The company has contracted with Chemiebau Dr. Zieren of Cologne to instal a plant making the best use of this by-product source of sulphur supply. Following extensive experimental work Chemiebau Dr. Zieren determined a satisfactory gas cleaning process which allowed the manufacture of high purity 98% sulphuric acid by using a patented process for direct catalytic conversion of such special gases. The approximate analysis of these gases in which arsenic and lead are contained in small quantities as impurities is as follows :—

SO_2	..	56.5	grams	S per	M^3 dry
H_2S	...	6.5	,,	,, ,,	,, ,,
CS_2	...	17.1	,,	,, ,,	,, ,,
COS	...	14.1	,,	,, ,,	,, ,,
S_2	...	1.8	,,	,, ,,	,, ,,
TOTAL		96.0	,,	,, per	M^3 dry

Corresponding to:

Sulphur Gases	...	5.0%	by	volume
CO ...	...	0.6%	,,	,,
CO_2 ...	...	12.0%	,,	,,
N_2 ...	...	81.5%	,,	,,

After leaving the Orkla blast furnaces the gases, at a temperature of 450°C, are first cleaned in an electrostatic precipitator and then cooled to condense the sulphur. At 125°C the gases then flow to a scrubber where impurities such as arsenic and lead are removed in an electrostatic precipitator and then freed from sulphur mist by being passed through a Chemiebau type turbulence separator. The cleansed gas at a temperature of 125°C enters the sulphuric acid plant. To ensure that the moisture content of the smelter exit gas is as low as possible the coke and lime stone used in the blast furnaces are dried and the process air in the blast furnaces and catalytic convertor is also desiccated. The Chemiebau

contact acid plant has to be capable of handling, in addition to 26,000 cu. metres of Orkla smelter gas per hour, process air for the oxidation of the sulphur compounds. The rated capacity of the plant is 180 tons per day of 98% sulphuric acid.

ISRAEL

New Expansions

The rapid progress made by *Fertilizers & Chemicals Ltd.*, of Haifa, in the manufacture of fertilizers had been temporarily reduced during the Sinai campaign in the autumn of 1956, so that the results published in the company's annual report for the year ending June 30th 1958 show substantially greater increases in all sectors. The following table illustrates the progress which has been made in the past three financial years :—

	1955/6	1956/7	1957/8
	000 Metric Tons		
Sulphuric Acid	70.3	79.3	101.8
Superphosphate	101.9	94.4	104.3
Di-calcium Phosphate	4.7	6.5	15.3
Ammonia	—	10.0	15.2
Ammonium Sulphate	—	38.9	59.0
Potassium Sulphate	1.2	4.1	8.9

Sulphuric acid production rose 28.4% to 101,800 tons, the bulk of which was destined for use in the fertilizer plants. The company's policy to meet Israel's rapidly growing fertilizer requirements at low cost has resulted in a major extension programme, at a cost of I£ 12 million to double nitrogen production facilities and provide liquid and compound fertilizers. This will involve an extension of the ammonia plant's capacity to 20,000 tons by 1960 and a subsequent increase to 26,000 tons. During the past year several new products were introduced, notably triple superphosphate, sodium tripolyphosphate and potassium silicofluoride.

As the result of the growing fertilizer chemical and metallurgical activities, Israel has become a sulphur consumer whose requirements, met by imports from the United States, Mexico and France, are now in the region of 50,000 tons annually.

MOROCCO

Sulphuric Acid/Fertilizer Production

During 1958 *Soc. Cherifienne d'Engrais et de Produits Chimiques, S.C.E.*, produced 41,624 tons of sulphuric acid (100% H_2SO_4) and 104,143 tons of superphosphate. The only fertilizer plant in Morocco, it is situated on the Atlantic coast 6 kilometres east of Casablanca and in addition to producing superphosphate and complex fertilizer also manufactures nitric acid for explosives and silicates of soda and potash.

The sulphuric acid plant has an annual capacity of 48,500 tons (100% H_2SO_4) and consists of a chamber and a contact unit. The chamber unit, originally built in 1924, has been progressively expanded in 1926, 1939 and 1956, and present annual capacity (100% H_2SO_4) is 25,000 tons. This unit burns an indigenous cupreous marcasite. The contact unit erected in 1949 has an annual capacity of 23,500 tons (100% H_2SO_4) and is based on imported elemental sulphur.

Aerial view of the fertilizer plant near Casablanca of Soc. Cherifienne d'Engrais. Sulphuric acid and nitric acid plant right foreground.

Superphosphate production has risen steadily since the end of the war and reached a record production in 1958 of 104,000 tons. This unit employs the Kuhlman continuous den and has an annual capacity of 140,000 tons superphosphate. During 1951 and 1952 there was a special export of fertilizer to the United Kingdom and Formosa but otherwise fertilizer has been delivered to home markets only.

Statistical Appendix

United States

	PRODUCTION		STOCKS		EXPORTS	IMPORTS*
	Frasch	Recovered	Frasch	Recovered		
1955	5,743,344	401,650	3,181,198	110,591	1,595,423	38,317
1956	6,427,229	480,980	3,936,450	119,446	1,651,597	203,044
1957	5,491,210	519,078	4,422,548	157,075	1,561,093	484,680
1958	4,644,812	619,594	4,442,066	177,271	1,567,072	582,659
1958 January	461,285	54,198	4,540,198	161,379	87,430	35,919
February	415,186	49,699	4,620,606	163,817	103,376	45,422
March	429,475	51,786	4,620,947	163,512	127,713	48,979
April	402,581	46,340	4,638,320	165,399	144,117	20,072
May	415,115	50,016	4,620,347	168,273	137,350	48,235
June	383,664	48,662	4,661,649	160,946	167,949	27,875
July	359,384	47,796	4,721,167	165,612	102,114	64,505
August	355,639	50,932	4,665,598	168,844	149,391	61,250
September	335,823	51,709	4,652,199	172,446	122,813	47,160
October	347,838	53,260	4,529,737	171,470	168,755	68,181
November	360,378	52,916	4,462,475	172,050	142,641	37,668
December	378,444	62,280	4,442,066	177,271	113,423	73,789

* Imports of sulphur from Mexico only.

Official Bureau of Mines Data (long tons of 2,240lbs.)

Cyprus

EXPORTS

Long Tons

IRON PYRITES	*1957*	*1958*
United Kingdom	179,715	146,989
Belgium	14,745	37,287
Czechoslovakia	14,179	—
France	138,507	184,027
W. Germany	223,278	247,231
Italy	75,645	69,628
Netherlands	108,175	134,673
Egypt	8,256	—
Total	**762,501**	**819,835**

CUPREOUS PYRITES	*1957*	*1958*
Belgium	—	15,570
W. Germany	75,022	41,948
Italy	81,447	61,083
Netherlands	70,165	110,220
Total	**226,334**	**228,821**

West Germany

PYRITES IMPORTS *Metric Tons*	*1957*	*1958*
Belguim	—	350
Finland	47,392	22,156
Greece	4,319	3,101
Italy	550	—
Jugoslavia	27,828	60,965
Norway	179,166	156,414
Portugal	43,346	59,451
Sweden	10,123	11,922
Spain	607,728	524,463
Turkey	38,634	30,108
Canada	79,716	33,177
U.S.A.	—	1,415
Cuba	78,188	36,081
Cyprus	385,033	387,897
Total	**1,502,020**	**1,327,872**

SULPHUR IMPORTS *Metric Tons*	*1957*	*1958*
France	—	13,046
U.S.A.	52,121	42,286
Mexico	11,029	8,716
Italy	1,000	—
Chile	360	—
Total	**64,510**	**64,061**

Holland

SULPHUR IMPORTS	*1957*	*1958*
Belgium	302	170
U.S.A.	9	21,195
Mexico	22,576	42,957
W. Germany	100	668
Great Britain	38	36
Total	**24,107**	**65,818**

PYRITES IMPORTS	*1957*	*1958*
Ireland	320	538
Norway	5,026	8,782
Portugal	76,506	103,691
Spain	153,967	8,195
Italy	—	86,931
Greece	14,602	12,510
Cyprus	111,527	112,627
Sweden	4,728	—
Total	**366,676**	**333,384**

Mexico

SULPHUR EXPORTS

LONG TONS

	1955	*1956*	*1957*	*1958*
United States	34,104	232,415	472,477	607,608
Canada	—	1,017	—	1,009
United Kingdom	27,157	48,013	81,000	58,823
France	25,007	58,083	69,278	115,708
W. Germany	3,741	—	9,003	6,845
Netherlands	14,753	19,868	55,832	35,655
Belgium	6,191	11,516	17,649	8,043
Sweden	5,883	15,584	—	3,150
Israel	4,000	—	24,037	36,260
Tunisia	—	3,004	21,958	32,574
South Africa	17,571	42,304	29,720	55,355
India	4,400	9,102	—	—
Formosa	—	—	—	3,954
Australia	38,756	40,607	59,277	75,877
New Zealand	—	—	36,262	13,674
Total	184,185	481,568	876,499	1,066,345

Norway

PYRITES EXPORTS

Metric Tons

	1957	*1958*
Poland	15,183	—
Czechoslovakia	20,682	21,171
E. Germany	62,739	41,584
W. Germany	160,049	155,025
Sweden	111,896	103,752
Denmark	62,260	45,593
France	5,015	11,024
Holland	11,852	10,405
Others	—	6,272
Total	**449,675**	**394,826**

SULPHUR EXPORTS

	1957	*1958*
Finland	20,552	20,391
Sweden	48,619	31,475
Denmark	1,331	*
France	170	*
Great Britain	198	*
Others	978	3,303
Total	**70,848**	**55,169**

** Included under others*

Portugal

PYRITES EXPORTS

Metric Tons

	1957	*1958*
U.S.A.	2,017	1,787
Mexico	—	149
Morocco	2,300	1,500
Tunisia	3,165	6,150
Ireland	1,378	1,880
United Kingdom	9,178	3,601
Germany	41,599	64,164
Belgium	94,820	111,551
France	67,417	50,275
Holland	76,371	116,228
Algeria	2,050	2,050
Total	**300,295**	**359,335**

O.E.E.C. 1957

Thousand Metric Tons Sulphur Content

	PRODUCTION				*CONSUMPTION*			
	Native & Recovered Sulphur	*Sulphur in Pyrites*	*Sulphur in other forms*	*Total*	*Elemental Sulphur*	*Sulphur in Pyrites*	*Sulphur in other forms*	*Total*
Austria	—	0.6	94.1	94.7	28.5	29.4	84.3	142.2
Belgium	0.4	—	2.6	3.0	99.6	129.5	146.4	375.5
Denmark	—	—	1.3†	1.3	2.5	65.9	—	68.4
France	32.0	143.0	30.1	205.1	280.0	357.0	99.0	736.0
Germany	77.8	241.0	*	(318.8)	*	*	*	*
Greece	3.5	129.6	12.3	145.4	13.0	50.2	3.7	66.9
Ireland	—	—	2.9	2.9	5.8	18.6	—	24.4
Italy	179.0	640.0	124.7	943.7	103.4	685.0	107.2	895.6
Netherlands	14.6	—	5.0	19.6	34.2	180.4	21.4	236.0
Norway	96.7	234.4	4.6	335.7	28.4	45.2	17.3	90.9
Portugal	16.9	306.7	—	323.6	17.8	143.9	—	161.7
Sweden	33.8	246.0	34.8	314.6	102.3	202.8	0.8	305.9
Switzerland	—	—	1.3	1.3	33.3	24.8	0.2	58.3
Turkey †	13.9	19.1	—	33.0	15.2	—	—	15.2
United Kingdom	39.4	0.2	287.1	326.7	425.7	178.9	334.9	939.5
Total	508.0	1,960.6	600.8	3,069.4	1,189.7	2,111.6	815.2	4,116.5

† 1956 data

*Not Available